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CHANGES for advertisements should be in this office by Friday noon for the following week's issue.
NEW ADVERTISEMENTS should be in the office not later than Monday noon to ensure publication in that week's issue.

THE FUTURE OF THE STEAM TURBINE.

A contract was made in England a few weeks ago for ten steam turbines, each of seven thousand horse-power capacity. These machines are intended to operate in the great station of the Metropolitan District Underground Railway.

The success of this gigantic installation will be awaited with the utmost interest on both sides of the Atlantic. The fact that competent and conservative engineers, employed by a corporation so careful in all its business dealings as one of the London underground railway companies, should have specified steam turbines as the motive equipment of so important a plant indicates, if nothing else, that they have fully satisfied themselves regarding the efficiency, economy and general desirability of this form of steam prime-mover. The installation is the first great step away from the practice of years in the use of reciprocating engines.

The first steam engine was simply an outgrowth of the water pump. Indeed, the application of steam engines for many years after their invention was restricted almost wholly to the operation of mining pumps. Even at so late a day as that of James Watt there was considerable difficulty in designing a satisfactory means for transforming the reciprocating movement of the piston into the rotary movement of a wheel. Since the time of Watt there has been no absolutely radical change in the design of steam engines until the recent recrudescence of the steam turbine, invented some two thousand years ago by Hero of Alexandria. The advantages of this type of steam engine are so remarkable and so conspicuous that they hardly need recital again in these columns. For the operation of electrical machinery the perfectly smooth and regular rotary motion of the turbine has advantages of the most remarkable kind over the necessarily irregular movement of the piston engine. The problem confronting the designer of governors for large steam engines operating in electrical stations to-day is immensely complicated by the necessity for very smooth and uniform rotary motion, required by the exigencies of alternating-current machines running in parallel with one another. As practically all new generating stations employ polyphase generators this requirement has become one of extreme moment. In certain recent installations in this country it has been necessary to design the large engines employed with the greatest care to secure an approach to uniformity of torque throughout a revolution period, but it is certain that no manner of design employing reciprocating motion can ever achieve the perfection of rotary motion exhibited by the turbine. When coupled with this important advantage are found also extremely high efficiency in the consumption of steam, reduced floor space and weight and ability to run at such high speeds as to cut down materially the size of the generators, it would seem that the turbine has incomparable advantages.

The turbine is still, however, in a comparatively immature state of development. Its possibilities have apparently been exploited in a small degree only, and very much remains to be done with it. Excellent as it has already shown itself to be, there are still large opportunities left for its improvement and betterment. When it is considered that the piston engine, after more than a century of development, has reached its apparent limit of perfection and that the turbine, of very recent industrial introduction, has already surpassed the performance of piston engines, the direction of future advance in steam motive-power machinery seems to be pretty clearly evident. It is true that some disadvantages appear to be inherent in machines of the turbine type, but these are more than overbalanced by the extraordinary advantages of economy, simplicity, compactness and smooth rotary motion possessed by the newer type of engine. In view of these facts it seems that the construction of another great generating station using piston engines would be, to say the least, an example of engineering conservatism of the most hardened type. In the present state of the art no great station should be undertaken without a careful and very thorough examination of the claims of the turbine for recognition.

THE EVILS OF PROSPERITY.

For several years past the electrical industry in the United States has enjoyed a season of almost unexampled prosperity. Orders have been numerous and large factories and shops have been compelled to work overtime, prices have been good, competition has largely been smothered, and, superficially at any rate, the industry is in a condition of great prosperity.

But prosperity of this kind is not an unmixed good. Indeed, one of the imme-

diate concomitants of such a state of things is the practical suppression of efforts to improve the quality of manufactured products or toward the invention of new types of apparatus or systems. The shop that is so busy filling its orders as to be compelled to strain every part of its material and personal equipment has absolutely no time for experiment or for the exploitation of new ideas. For many years the electrical industries have been coming up through a stage in which invention counted much, and a period of development in which news of new things was the daily expectation. To-day the vastly larger part of all electrical output is closely standardized, and the great shops, once the home of invention and the theatre of important discoveries, have become simply manufactories where machines are turned out with as little individuality as is shown by cakes of soap or barrels of flour.

Now this state of things is extremely profitable to stockholders of manufacturing enterprises, but a larger view of the subject may perhaps lead to the thought that this prosperity can not eternally continue, and that under the pressure of competition from less favored establishments there must eventually come a change. To illustrate: Germany and Austria have of late been suffering from industrial depression to a marked degree. The manufacturing establishments of these countries have not, like those of the United States, been crowded with work, but have, perforce, been obliged to seek continually new avenues for their energies and new methods and directions in which to interest the timid capital of a non-prosperous community. The result has been the development in those countries of novel ideas, new systems and new apparatus in great abundance. Some of these exhibit every indication of proving so successful in practice that they will eventually come into very serious competition with the standard appliances which our makers are now producing. As a single example, the application of polyphase current directly for traction purposes has been fostered and to some degree developed already in the countries mentioned, while here no manufacturer seems ready to take up the subject—for the reason that orders for direct-current apparatus are in hand in most shops sufficient to keep them busy for months, if not years, even if no more are taken in. Under these circumstances the conservative works manager naturally feels that to experiment with a new thing, to upset the normal (or perhaps we might say the abnormal) conditions of business which bring in so large a revenue, would be the height of folly. So perhaps it might be, but will not the day unquestionably come when the apparatus now standard and now manufactured in enormous quantities will be out of date, and when the necessity for improvement will become evident and even pressing?

This, then, the tendency toward making purely manufacturing plants of our electrical workshops, is a necessary evil attendant upon prosperity. Why should not the fact that improvement ought constantly to go on, even though only standard goods are made, be fully recognized, and why should not our works continue their experimental researches at the same time that they are making so large an income from their pure manufacturing? If they do not, then the prediction may safely be ventured that they will regret it. For, notwithstanding the excellence of the present standard apparatus and types, the permanence of such designs is threatened by every advance in engineering and physics, and the day may come when we will find, to our sorrow, that foreign competitors have taken away from us the first place in engineering which we have so long and so conspicuously held.

THE TELEPHONE IN THE FUTURE.

The telephone has been so far developed, and systems of circuits and exchanges have grown to so great a size, as to furnish reasonably accurate data for at least a rough guess at the probable future of telephone extension.

It can not be denied to-day that the telephone has long since ceased to be a luxury and has become a very vital necessity to business affairs. By various improvements in its design and construction the first cost of telephone apparatus has been greatly reduced and has now reached what may be regarded as its limit; that is, it will probably never be possible to make telephones much, if any, more cheaply than they are made to-day. Improvements in exchange service and lines have probably brought the cost of switchboards, conduits and cables down to a very reasonable figure, and in this direction there does not appear to be much hope for improvement in cost. The consequence is that exchange service, as it is sold to-day, will not likely be very much cheapened in the future.

This is certainly true, so long as the manual system of operation is adhered to. The automatic telephone exchange system has accomplished remarkable and highly satisfactory results in small exchanges. What it would do in a larger exchange, or in the largest central office, is a question which can probably be determined only by experiment. It is in the way of being tried in Chicago, where a company has already laid many miles of tunnels under the principal streets to receive the conductors of a telephone system of great magnitude which is to be operated entirely on the automatic system. Certainly no one with the future of telephony at heart could wish to see this experiment fail.

While the telephone is eventually destined to become much more widely used than it is now, its use will most likely extend not through any great cheapening of rates, but rather through the greater understanding of its necessity. Doubtless, also, the message rate or meter system will be widely extended, this being a most equitable basis of payment for telephone service and also giving the benefit of low rates to those who make only occasional use of the telephone. It is not looking too far ahead to assume that in such centres of population as New York, systems of over one hundred thousand telephones will soon be in operation. It is well known to telephone people, but hardly yet appreciated by the general public, that the cost of conducting an exchange business is by no means reduced with the increase of the number of subscribers; on the contrary, it is very materially increased. Probably the old law of wholesale and retail fails nowhere else so conspicuously as it does in telephone exchange operation. For this reason it is hardly reasonable to look for any material decrease in the cost of service with the growth in size of exchanges, but from other considerations a very wide extent of telephone use eventually may be safely predicted.

THE THEORY OF ALTERNATING DYNAMO ELECTRIC MECHANISMS—LXI.

BY W. ELWELL GOLDSBOROUGH.

We come now to a detailed discussion of Fig. 149, which shows the character of the loci developed when the capacity reactance of a receiver circuit is subjected to successive change, under the conditions imposed. The subscript letters (*b*), (*c*), (*d*), (*e*), (*f*), and (*g*) mark successive steps from the initial position designated by (*a*). Initially, when $C_1 = \infty$ and x_1 = zero, the resultant field enclosed by the armature coils is less than the maximum field flux OM_0, which penetrates the coils at no load. When, however, C_1 is diminished in value, the current assumes such phase positions that OM grows until, as at OM^d, it materially exceeds the no-load field magnetism, OM_0, in value. The current which produces the auxiliary armature field causing these modifications traces out the circular locus, $B^aB^bB^cB^d$, etc. This follows from equation 155, since the heel of the electro-motive-force triangle, made by the total resistance and total reactance electro-motive forces on the vector OA_0, marks out the circular locus described on OA_0 as a diameter, and the current, I, is proportional to the total resistance electro-motive force $OC_0 = I\ (r_a + r_1)$. Since the armature current traces out a circular locus, the armature electro-motive-force vector OC_a, and the armature impedance electro-motive-force vector OA_a also trace out circular loci, since their values are proportional to variations taking place in the current. Now, the resultant of the armature impedance electro-motive force OA_a and the total internal electro-motive force OA_a is equal to the electro-motive force appearing at the collector rings; therefore, the electro-motive force at the collector rings should, in its several phase positions, trace the locus circle $A_a{}^aA_a{}^bA_a{}^cA_a{}^d$.

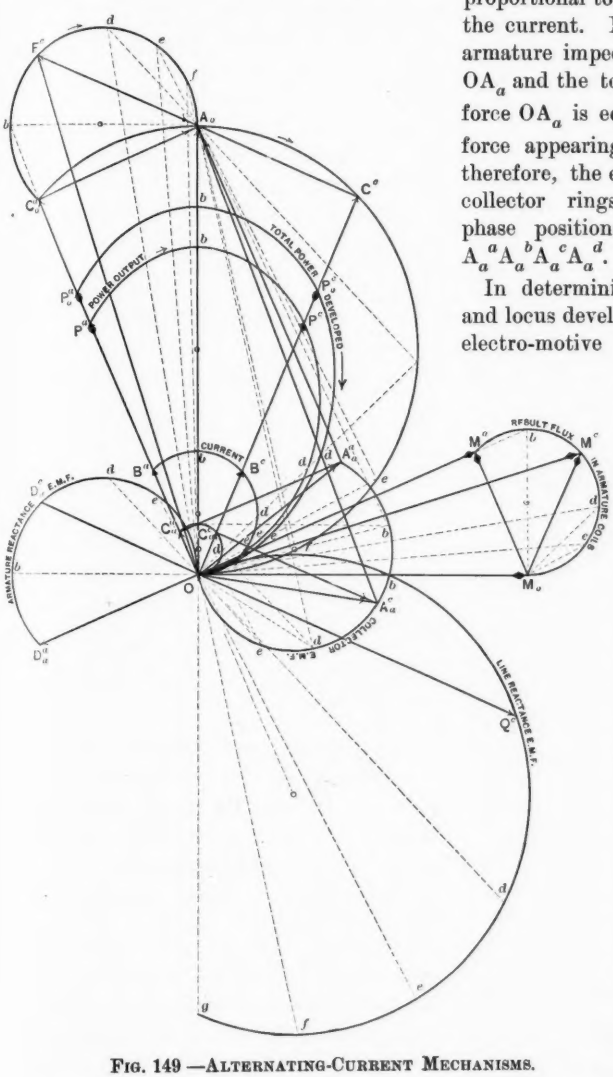


FIG. 149.—ALTERNATING-CURRENT MECHANISMS.

In determining the successive values and locus developed by the line reactance electro-motive force, we draw from O successive vectors equal and parallel to the successive positions taken by the vector C_0F. This construction develops the circle $Q^bQ^cQ^dQ^e$, which will be found to be a continuation of the line reactance electro-motive-force locus developed in Fig. 142.

In Fig. 149, the power loci are also shown. The power factors are drawn in phase with the armature currents, and indicate that the maximum power developed in the armature winding occurs when the armature current is in phase with the total internal electro-motive force OA_0. The maximum external power occurs at the same time, since it varies directly as the square of the armature current, and the armature current is a maximum when in phase with the total internal electro-motive force. As in cases where the inductance of the receiver circuit is a variable, so when the capacity reactance of the receiver circuit is a variable, the efficiency of the system always remains a constant and equal to

$$100\ [(I^2\ r_1) \div I^2\ (r_1 + r_a)].$$

A study of Figs. 134, 142 and 149, concurrently, will disclose the fact that these diagrams give a ready method of analyzing the behavior of a single-phase alternator under any imposed conditions, providing the constants of the machine are known. By successively varying the resistance, inductance and capacity of the receiver system, the combined effect of these three factors can be traced, while, similarly, by assuming changes in the frequency, problems involving complications due to speed variations can be studied. The general scheme for applying these constructions has already been outlined in the discussion of the problems considered on pages 541, 645, 684, 717, 749, and 779 of vol. xxxviii.

Example 26.

Given: A 100-kilowatt alternator, developing 1,000 volts and 60 cycles. The resistance of the armature of this machine is 1 ohm, while the inductance of its armature is 0.01062 henry; the reactance of the armature is, therefore, 4 ohms. Assume that this machine is working on a circuit having a constant non-inductive resistance of 8.16 ohms, and a capacity reactance varying in value from infinity to zero.

Determine the characteristics of the alternator.

Fig. 149 applies to this problem, and, with table 20, gives the data needed for constructing the characteristics. The data in table 20 can be obtained by either a mathematical or graphical process; the mathematical will be used here, and we will proceed to the solution of the case in which the capacity reactance has a value of 13.7 ohms. This is the case designated by the letter (*d*), both in Fig. 149 and in table 20. If we substitute our data for this case in equation (155), we have

$$I^d = \frac{1{,}000}{\sqrt{(1 + 8.16) + (13.7-4)^2}} =$$

75 amperes.

This current of 75 amperes is

$$\phi_0{}^d = \tan^{-1}\frac{13.7-4}{1 + 8.16} = 46^\circ\ 36'$$

in advance of the total internal electro-motive force, and

$$\phi^d = \tan\frac{13.7}{1 + 8.16} = 59^\circ\ 13'$$

in advance of the electro-motive force appearing at the collector brushes. The resistance drop in the armature is now $I^d\ r_a = 75$ volts; the armature reactance drop $I^d\ x_a = 300$ volts, and the armature impedance drop

$$I^d\sqrt{r_a{}^2 + x_a{}^2} = 309 \text{ volts.}$$

The receiver resistance drop equals $I^d r_1 =$ 612 volts. The receiver reactance drop equals $I^d x_1 = 1{,}027$ volts; therefore, the electro-motive force at the collector rings equals

$$\sqrt{(612)^2 + (1{,}027)^2} = 1{,}196 \text{ volts.}$$

values to Fig. 149, we have $OA_0 = 1{,}000$ volts; $OC_a{}^d = 75$ volts; $C_a{}^d A_a{}^d = 300$ volts; $OA_a{}^d = 309$ volts; $C_a{}^d C_0{}^d = 612$ volts; $C_0{}^d F^d = 1{,}026$ volts; $A_a{}^d A_0 = 1{,}196$ volts; $OB^d = 75$ amperes, and the angle B $OA_0 = 46.6°$. Since the power current values taken as abscissa, we get a very interesting set of curves. As the reactance of the receiver circuit gradually increases with the decrease in capacity, the electro-motive force at the collector rings steadily rises until it ultimately reaches a maximum value of 1,200 volts. From this on, it gradually falls to the no-load value of 1,000 volts. This is the feature deserving of special consideration, in connection with the operation of the alternators on circuits having predominant capacity reactance factors.

By combining the regulation curves of Figs. 136, 143 and 150, we obtain those shown in Fig. 151. In considering an alternator working under full non-inductive load, the point A may be taken as representing the electro-motive force at the collector rings when the no-load electro-motive force equals A_0. If, now, the resistance of the receiver circuit is gradually increased, the potential at the collector rings will decrease along the central regulation characteristic. If, however, while the resistance of the receiver circuit remains constant, inductance is introduced into the circuit and also increased, the potential at the collector rings will change, relatively to the values of the armature current, as indicated by the lower voltage characteristic; while, if the initial conditions in the receiver circuit are modified by the introduction of an increasing capacity reactance into the receiver circuit, the electro-motive force will follow the upper characteristic line as it changes in value, relatively to changes in the armature current.

TABLE 18.

Data pertaining to Figs. 134, 135, 136 and 151.

Exponent Letter.	Line Resistance. r_1	Total E. M. F. in Phase with Current. $I r_0$	Current and Armature Resistance E. M. F. $I \& I r_a$	Armature Reactance E. M. F. $I x_a$	Armature Impedance E. M. F. E_a	E. M. F. at Collector Rings. E	Lag of Current Behind E_0. ϕ_0	Total Power Developed in Kilowatts. P_0	Power Output in Kilowatts. P	Electrical Efficiency. %
a	∞	1,000	..	..	..	..	..	..	..	..
b	38.8	995	25	100	103	970	5° 45′	24.9	24.2	97.4
c	18.6	980	50	200	206	930	11° 32′	49.0	46.5	94.9
d	11.7	954	75	300	309	879	17° 28′	71.5	65.3	91.3
e	8.2	916	100	400	412	816	23° 35′	91.6	81.6	89.0
f	5.9	866	125	500	515	741	30° 00′	108.2	92.7	85.6
g	4.3	800	150	600	618	650	36° 52′	120.0	97.5	81.2
h	3.1	714	175	700	721	539	44° 26′	125.0	94.3	75.4
i	2.0	600	200	800	824	400	53° 8′	120.0	80.0	66.6
j	0.94	436	225	900	927	211	64° 10′	98.1	47.4	48.3
k	..	243	243	1,000	1,000	..	75° 56′	58.9	..	..

TABLE 19.

Data pertaining to Figs. 142, 143 and 151.

Exponent Letter.	Line Reactance. x_1	Total E. M. F. in Phase with Current. $I r_0$	Total Reactance E. M. F. $I x_0$	Current and Armature Resistance E. M. F. $I \& I r_a$	Armature Reactance E. M. F. $I x_a$	Line E. M. F. in Phase with Current. $I r_1$	Line Reactance E. M. F. $I x_1$	E. M. F. at Collector Rings. E	Lag of Current Behind E_0. ϕ_0	Lag of Current Behind E. ϕ	Total Power Developed. P_0	Total Power Output. P	E. M. F. at Collector if $r_a = 0$.
a	..	916	400	100	400	816	..	816	23° 35′	..	91.6	81.6	916
b	5.7	687	727	75	300	612	427	745	46° 36′	34° 49′	51.6	45.9	808
c	13.8	458	888	50	200	408	688	801	62° 44′	59° 20′	23.9	21.3	828
d	34.8	229	969	25	100	204	869	894	76° 46′	76° 51′	5.7	5.1	898
e	∞	..	1,000	..	..	..	1,000	1,000	90° 00′	90° 00′	..	..	1,000

TABLE 20.

Data pertaining to Figs. 149, 150 and 151.

Exponent Letter.	Capacity Reactance. x_1	Total E. M. F. in Phase with Current $I r_0$	Total Reactance E. M. F. $I x_0$	Current and Armature Resistance E. M. F. $I \& I r_a$	Armature Reactance E. M. F. $I x_a$	Line E. M. F in Phase with Current. $I r_1$	Line Reactance E. M. F. $I x_1$	E. M. F. at Collector Rings. E	Phase Angle between I and E_0. ϕ_0	Phase Angle between I and E. ϕ	Total Power Developed. P_0	Total Power Output. P	E. M. F. at Collector if $r_a = 0$.
a	..	916	409	100	400	816	..	816	23° 35′	..	91.6	81.6	916
b	4.0	1,000	..	109	436	891	437	993	..	26° 8′	109.2	97.3	1,091
c	8.0	916	400	100	400	816	800	1,142	23° 35′	44° 26′	91.6	81.6	1,216
d	13.7	687	727	75	300	612	1,027	1,196	46° 36′	59° 13′	51.6	45.9	1,234
e	21.8	458	888	50	200	408	1,088	1,163	62° 44′	69° 28′	23.9	21.3	1,182
f	42.7	229	969	25	100	204	1,069	1,089	76° 46′	79° 12′	5.7	5.1	1,092
g	∞	..	1,000	..	..	..	1,000	1,000	90° 00′	90° 00′	..	..	1,000

We have now all of the quantities needed, with the exception of the power output. The total power developed in the armature equals $(I^d)^2 (r_a + r_1) =$ 51.6 kilowatts, while the power developed in the external circuit equals $(I^d)^2 r_1 =$ 45.9 kilowatts. Applying these numerical vectors are drawn in phase with the currents, we have that $OP_0{}^d = 51.6$, and $OP^d = 45.9$.

Similarly, the remaining data tabulated in table 20 can be developed. Taking this data and plotting it to rectangular coordinates in Fig. 150, relatively to the

Our Place in Science.

A careful estimate of America's position in the scientific world must consider the different kinds of scientific work. In the applications of science we probably lead. We have had and have great inventors, and in the progress of engineering, manufactures, agriculture, etc., where the individual is often unrecognized, we are contributing more than our share. If further we divide the pure sciences into nine groups—mathematics, astronomy, physics, chemistry, geology, zoology, physiology, botany and anthropology-psychology—the United States would be doing its share if it excelled in one science. We are clearly inferior to several nations in mathematics, physics, chemistry and physiology; we are inferior in reputation, but not obviously so in performance, in zoology, botany and anthropology-psychology; we are probably doing work of greater volume and value than any other nation in astronomy and in geology.—*Popular Science Monthly* for March.

Science Brevities

Liquid Sulphur Dioxide as a Solvent—The behavior of liquid sulphur dioxide as a solvent has been very completely investigated by Messrs. Walden and Centnerszwer, an account of whose researches is contained in vol. xxxix of the *Zeitschrift für physikalische Chemie* (pp. 513-596). It is found that liquid sulphur dioxide easily dissolves a large number of (binary) inorganic salts and most salts of organic bases. The solutions of these salts are good conductors of electricity. The simple laws which regulate the conductivity of aqueous solutions of salts are in general not valid for the sulphur dioxide solutions. Among these may be mentioned Kohlrausch's law of the independent wandering of the ions, Ostwald's dilution law, the law according to which the molecular conductivity approaches to a maximum with increasing dilution, and the rule according to which the increase in the conductivity with the dilution is the same for all binary salts. The conductivity of solutions has been investigated at temperatures ranging from the freezing point of liquid sulphur dioxide to its critical point. The molecular conductivity increases at first with the temperature, reaches a maximum at a temperature dependent upon the nature of the dissolved salt, and then decreases with a further rise of temperature, becoming finally zero at the critical temperature, although the salts remain dissolved even at temperatures above the critical temperature. The authors conclude from this observation that electrolytic dissociation in solutions is an essential property of, or conditioned by, the liquid state of aggregation. Determinations of the molecular weight of dissolved salts by the boiling-point method give values higher than the normal, from which it would appear that the molecules of the dissolved salts are to a considerable extent polymerized, or form complex associated molecules containing molecules of the solvent.

Spontaneous Ionization of Gases—It has previously been shown that there is a continuous production of ions in air contained in a closed vessel, even when it is not exposed to any ionizing agent. C. T. R. Wilson has measured the relative rates of production of ions under such conditions in air and certain other gases. These rates of production were obtained by comparing the saturation currents in the various gases. The vessel in which the ionization was measured was a glass bulb thinly silvered internally. The conducting system, from which took place the loss of charge to be measured, consisted of a brass wire with a narrow strip of gold leaf attached, the wire being fixed by means of a small bead of sulphur to a brass rod passing through a plug of sealing wax in the neck of the bulb. This supporting rod was kept at a constant potential by means of a condenser, consisting of zinc plates embedded in sulphur. Electrical connection could be made when required between the leaking system and the supporting rod by means of a strip of watch balance-spring, soldered at its upper end to the supporting rod, and with its lower end bent so as to form a bridge over the sulphur bead. By approaching a magnet to the neck of the bulb the free end of the spring could be brought into contact with the upper end of the brass wire carrying the gold leaf. The position of the gold leaf was read by means of a microscope provided with an eye-piece micrometer scale. It was found that the leak was proportional to the pressure, except at the higher pressures. For the lower pressures the rate of leak may be taken as a measure of the ionization. The following were the relative ionizations: Air 1.00, hydrogen 0.184, carbolic acid 2.64 and chloroforum 4.7. Except in hydrogen the ionization is very nearly proportional to the density of the gas. It would follow, says the *Electrician* (London), that a certain weight of gaseous matter always contains the same number of ions, but this number is lessened at higher pressures, and in hydrogen the ionization per weight is two-and-one-half times as great as in the other gases. The author mentions the possibility of the ionization being due to a radiation from the walls of the vessel, which might be absorbed at the higher pressures, but he does not consider this explanation proved.

Musical and Talking Electric Arcs—At the Royal Institution recently an interesting lecture was delivered upon this subject by Mr. W. Duddell. The *Mechanical Engineer* (London) reports it as follows: Dealing first with talking arcs, the lecturer showed how the vapor column of the arc varied in size with variations in the current which produced it, and was sensitive to both very small and very frequent variations. Hence when the current from an ordinary microphone transmitter was added to the current maintaining the arc, the vapor column of the latter changed its size in correspondence with the changes in the telephonic current, minute though they were, and set up sound waves in the surrounding air, which gave reproductions of the sounds spoken into the transmitter. Thus the arc acted as a receiver, and, as the lecturer demonstrated to the audience, reproduced sounds spoken into the transmitter of a telephone in a distant part of the building. Moreover, the light given by the arc varied under the influence of such a telephonic current, and this fact could also be used to transmit sounds. The light of the arc was made to fall upon a selenium cell, which was included in another telephonic circuit. Selenium being a substance the electrical conductivity of which varied with the intensity of the light energy to which it was exposed, the variations in the light of the arc, though imperceptible to the eye, produced variations in the current passing through the second telephone, which thus repeated the sounds spoken into the first telephone, though there was nothing to connect the two except the beam of light proceeding from the arc. A permanent record of the sounds could be obtained by passing a sensitive film through the beam of the talking arc, and then, having developed it, drawing it over a selenium cell with a strong light behind it; a telephone connected with the cell would then reproduce the original sounds. In the second part of the lecture Mr. Duddell showed how an alternating current could be derived from any direct-current arc, without the use of an alternator, simply by connecting a self-inductive circuit containing a condenser as a shunt round the arc. The only precautions to be observed were that the resistance of this circuit must be kept below a certain limit and that solid carbons must be used in the arc. In this circumstance the arc gave a musical note, the pitch of which depended on the frequency of the alternating current in the shunt circuit. This frequency could be altered either by varying the capacity of the condenser or the self-induction, and the variations required to get a given note were a matter of mathematical calculation. Mr. Duddell showed a small keyboard which in this way was made to give two complete octaves of the musical scale. He pointed out that the alternating current obtained in this simple manner from a direct current could be used to exhibit all the phenomena of high-frequency currents, and among other experiments he employed it, after transforming it up twice by ordinary methods, to give the Tesla discharge.

Work on another Suakim and Berber Railway (Egyptian) is about to be commenced. The line is expected to be opened for traffic next year.

The Berlin-Zossen High-Speed Electric Railway Experiments—III.

By Enrico Bignami.

(*Concluded.*)

TRANSFORMERS.

It was decided to place the main transformers under the floor of the car with their longitudinal axes parallel with that of the car, this construction permitting the easy determination of an air circulation for cooling. The iron of the transformer core is so arranged that each of the three cores is built up of three bundles of rectangular sections placed with an opening of about an inch in width between them. The various parts of the core are very solidly assembled by means of heavy bolts, and the various sections of each core are held apart by stout washers slipped on the bolts. Fig. 19 gives a good idea of the construction of the transformer. The yokes closing the magnetic circuit at the ends of the cores are solidly fastened to the plates by heavy screws.

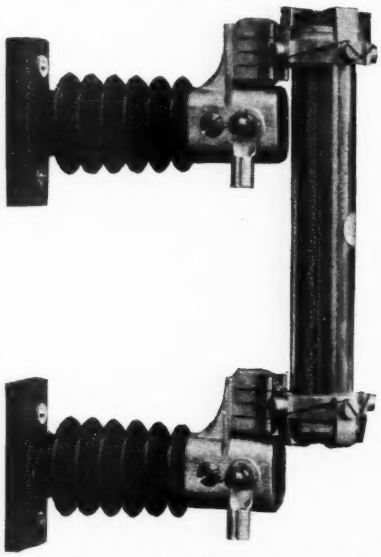


FIG. 18.—ONE OF THE HIGH-TENSION FUSES.

By dividing the yoke into two halves the total length of the working iron, measured from the extremities of the transformer, is no greater than that of the windings themselves.

The winding is composed of a secondary coil, insulated from the core by a micanite spool made in one piece, and a primary coil outside of the secondary and built up in several sections, connected together by screw connectors. Between the two coils there is also a heavy insulating tube of mica. Fig. 20, which shows one of the transformers partially disassembled, gives an excellent idea of the whole method of construction.

The high-tension conductors are brought through a conduit and terminate on three ebonite insulators where they are connected with the transformer terminals. Near these insulators is situated a small door through which access can be had to the terminal connections.

The transformer is hung under the car by means of two solid transversals and four heavy angle iron plates so that it may easily be detached from the car as a whole.

HIGH-TENSION FUSES.

Inserted in the circuit on the primary side of the transformer are the principal fuses, which are each composed of four small pasteboard tubes, shut up in a micanite cylinder and each containing fusible wires. The mica cylinder is solidly cemented, at its upper extremity, to a metal lid furnished with flanges and carrying four curved tubes through which the gases produced by the blowing of the fuses escape. The lid rests upon an insulator of peculiar form, of which the head also carries the cross-connecting conductors. The same type of insulator is adopted also for the high-tension circuit-breakers and for the small transformers. It is composed of a hollow cylindrical metallic body covered with hard rubber. On its outside circumference it carries ribs to increase the surface of the insulator.

The lower part of the cylinder is fastened into a round hole cut in the upper plate of the cableway in the car and fitted in water-tight.

HIGH-TENSION SWITCHES.

The high-tension switch, like those for intermediate tension, is built on the piston pattern, and is worked double-pole in each of its three branches. It differs from the intermediate-tension switch in that the contacts are not arranged around a circumference, but are placed side by side, and that half the switch is placed on the car roof and the other half underneath it. The current in each phase, coming from the brushes on the upright portion of the trolley, is led to one of the switch points through one of the special insulators. Thence it passes on a bridge to the second switch point, after which it goes through the second special insulator and along the roof of the car to the cableway and fuses.

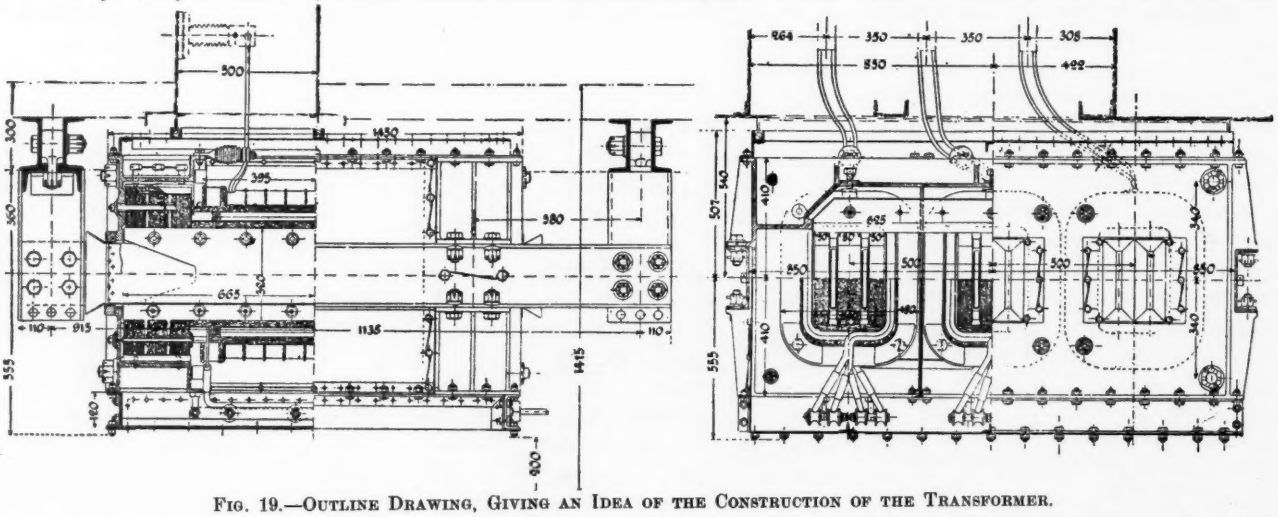


FIG. 19.—OUTLINE DRAWING, GIVING AN IDEA OF THE CONSTRUCTION OF THE TRANSFORMER.

Fig. 22 gives a good general idea of the arrangement of all of this class of apparatus on the car.

The three bridging pieces for the three phases are placed alongside of one an-

other and are connected by a transversal beam. They are all operated by a compressed-air cylinder having a stroke of about one inch, this being placed under the seat in the vestibule of the car. The transversal beam runs between two guide rods and is arranged so that lifting it opens the switch.

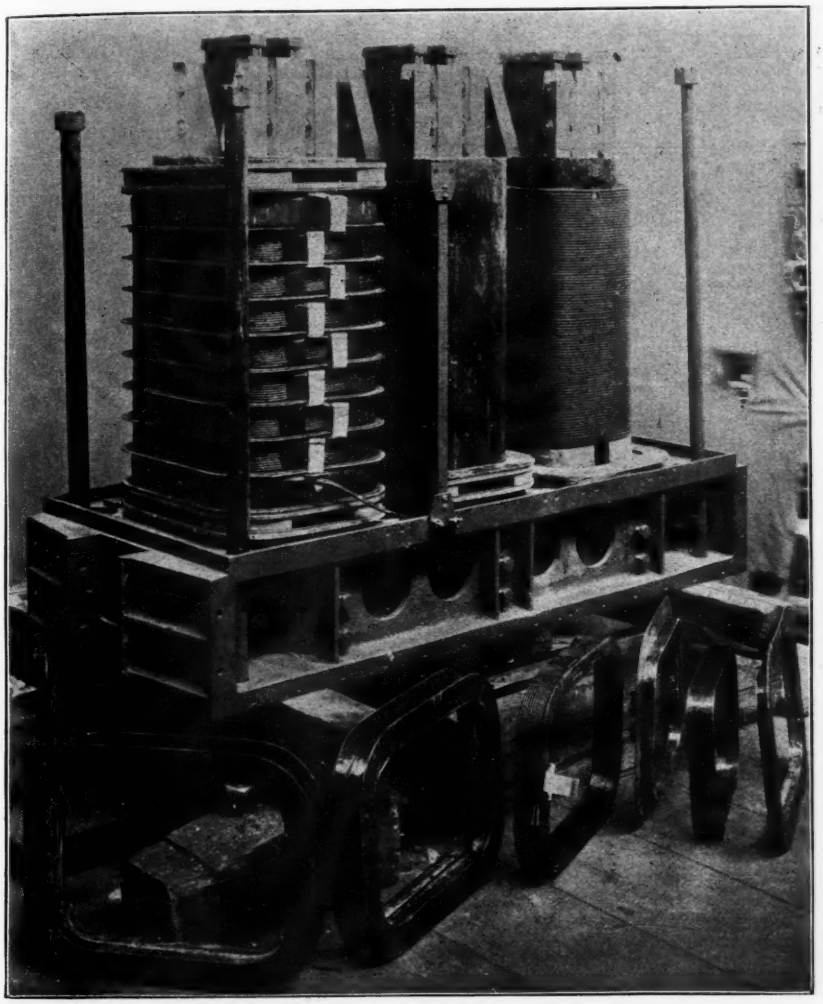


FIG. 20.—TRANSFORMER, PARTIALLY ASSEMBLED.

The transversal beam is held in position for closed circuit by two triggers, which are operated by the compressed-air piston at the bottom of its stroke. When these are released the beam carrying the bridging parts is suddenly thrown by means of springs in the usual way. The switches work well without exhibiting undue arcing.

THE TROLLEY.

The vertical shaft of the trolley mechanism consists of two tubes of Mannesmann steel, about eight inches in diameter, telescoping one inside the other. The lower part of this vertical column is pivoted in a socket plate under the floor of the car and passes through a bearing in the roof. By means of a hand-lever, working through double reduction gearing, the motorman can turn the column at will, and by means of a locking arrangement can set the column in four different positions. At the top of the lower part of the column is a collar attached by screws carrying the cylindrical support for the contact rings. This tube is of steel, covered with hard rubber and ribbed. The contact rings are fastened to this insulated tube by collars and ribbed insulators. Corresponding to the three rings are three spring brushes supported on a flat cast-iron bed-plate, also by means of ribbed, hard rubber insulators.

Through the interior of the insulated tube passes the tubular upper part of the trolley apparatus proper. By removing two or three screws this tube may easily be taken off from the lower part of the apparatus in case it is bent or injured. It is furnished with three pivots, placed one metre apart, for supporting the bow trolleys, which are made of thin bicycle tubing. These, as well as the bearing pieces which run against the trolley wire, are separately detachable.

The contact rods of the bow trolleys are double, in order to avoid as much as possible the wear due to the heavy current—200 amperes—and to avoid sparking on straight runs and especially at passing the suspending insulators of the trolley wire.

COMPRESSED-AIR APPARATUS.

For the necessary compressed air for operating brakes and manipulating the electrical apparatus there are two special pumps placed under the end cabs and operated by motors. These work at 190 turns a minute and have an output of 400 litres (eight cubic feet) per minute of air, compressing it to a pressure of 120 pounds to the square inch. Each contains two single-acting cylinders, operated by a crank-shaft driven by spur gear from the motor. The latter is of the induction

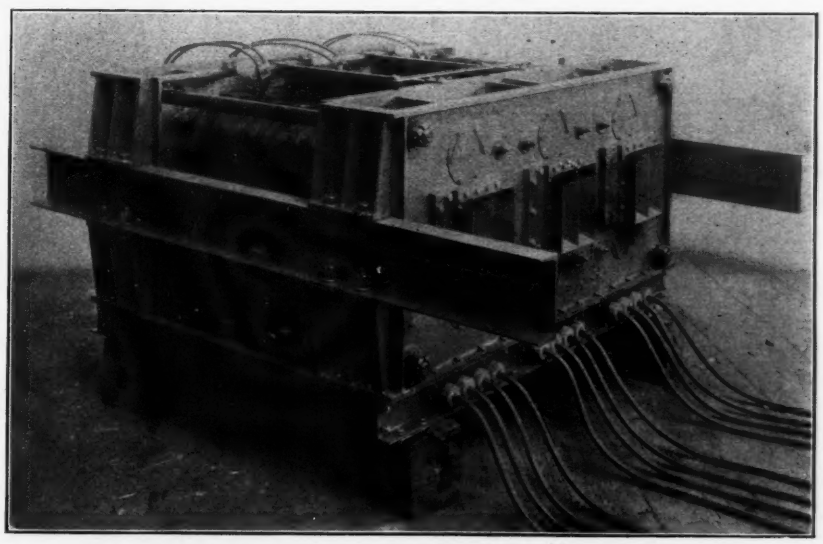


FIG. 21.—TRANSFORMER AND TERMINALS, ASSEMBLED.

type, having a short-circuited armature, and receives its current from a small transformer mounted with its switch in a cast-iron box fastened to the roof. The compressed air is stored in two reservoirs, one for the brakes and one for the control apparatus.

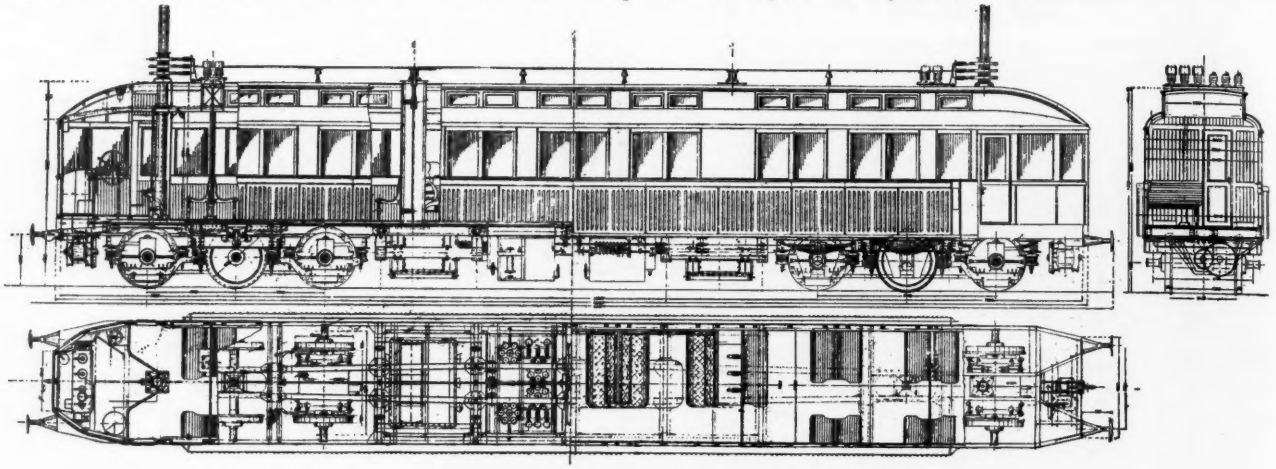


Fig. 22.—Plan and Side and End Elevations of Berlin-Zossen High-Speed Car.

ARRANGEMENT OF THE CABS.

As was mentioned above, the control apparatus is all worked by compressed air drawn from two reservoirs placed under the cabs. The reservoir for the control apparatus is fastened under the floor of the vehicle, while that for the brakes is mounted vertically in one of the rear corners of the cab. The pressure is maintained at 120 pounds in the brake reservoir and at seventy-five pounds in the controller reservoir.

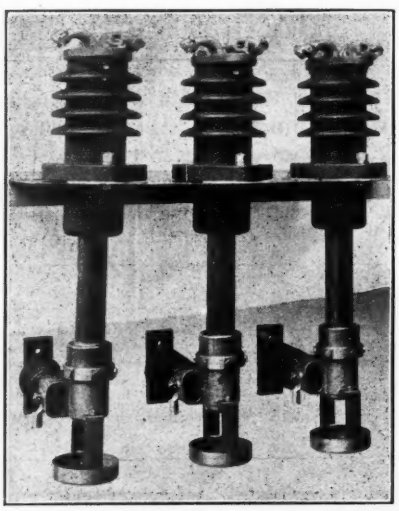


Fig. 23.—Transverse Beam of High-Tension Three-Phase Switch.

The two reservoirs are connected by means of a pipe containing a reducing valve. For the manipulation of the control apparatus there is placed at the front of the cab a table containing valves, each of which may be put in three positions. These may be called neutral position, work position and off position.

In the neutral position the cylinders working the various control apparatus are cut off both from the outer air and from the reservoirs.

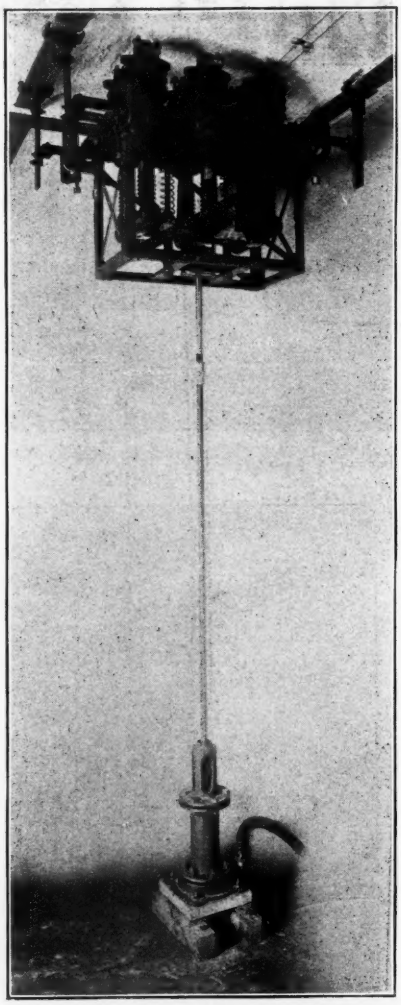


Fig. 24.—Air-Controlled High-Tension Three-Phase Switch.

In the working position the control cylinders are connected with the compressed-air reservoir.

In the off position the air pressure is cut off from the cylinders and they are opened to the outer air.

All of the valves of the two cabs are connected with the cylinders operating the control apparatus by means of flexible hose couplings. These are arranged under the floor of the car near the longitudinal sills. The equipment of the cab is completed by a starting switch for the air pumps. This consists of a valve mechanically attached to the switch of the pump motor, and may be set in three positions: Stop, start and normal running. In the starting position the motor runs freely, and when it has attained its proper speed the valve is turned into the operating position, allowing the pump to work against the full pressure in the reservoirs. In the middle of the back of the cab is the steel tubular column of the trolley apparatus, with its gearing and handwheels for turning it into the various positions necessary when running to bring the bow trolleys into proper engagement with the wire.

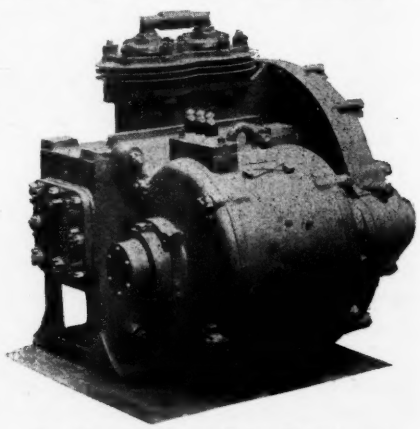


Fig. 25.—Air-Brake Pump Worked by Three-Phase Motor.

THE TROLLEY LINE.

The present installation of the trolley line extends from the railway station at

Marienfelde to that at Zossen, a distance of 23.5 kilometres (15.5 miles). The system of suspension adopted is highly flexible, as may be seen from the large illustration, which shows very clearly the method of suspending the line. The trolley wire rests on the top of an um-

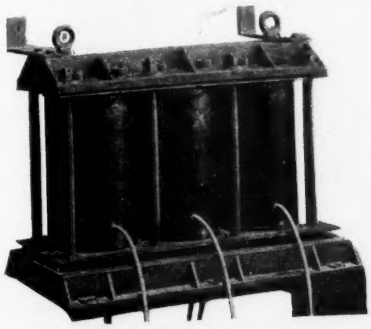


FIG. 26.—SMALL TRANSFORMER FOR THE AIR-BRAKE MOTOR.

brella-shaped insulator which is flexibly supported in all directions by the simple and ingenious construction so well shown in the figure. The wires are doubly insulated from the earth, each of the two parts of the insulation being able to support the maximum pressure of 12,000 volts. The high-tension insulators are all of ebonite. The second insulation between the line and the earth is formed by three link insulators mounted in series, as is well shown in the illustration. The pressure between the lines varies from 10,000 to 12,000 volts. Each wire is 100 square millimetres in section (about No. 000 Brown & Sharpe gauge).

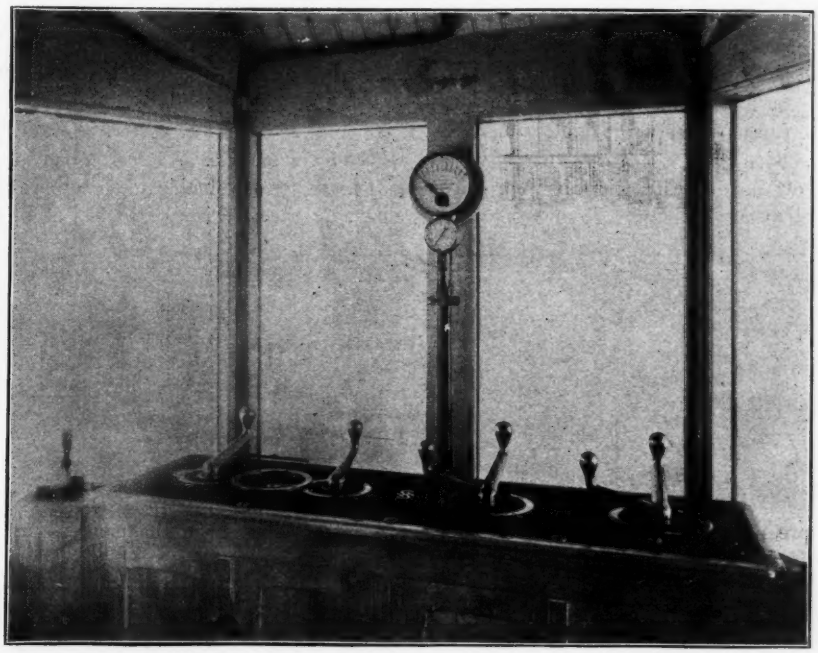


FIG. 27.—CONTROLLING APPARATUS IN THE MOTORMAN'S CAB.

The line is divided into sections, the conductor wires being anchored at each kilometre. The poles are of wood, and at the section breaks are double, to form a support for the anchorages. At these breaks the trolley is out of contact with the wires for a distance of about fifteen feet. Each section of the line is provided with lightning arresters mounted on the poles, these being of the usual European "horn" type. Safety devices are also provided so that if one of the wires is broken it is immediately earthed.

The rails are bonded and connected to

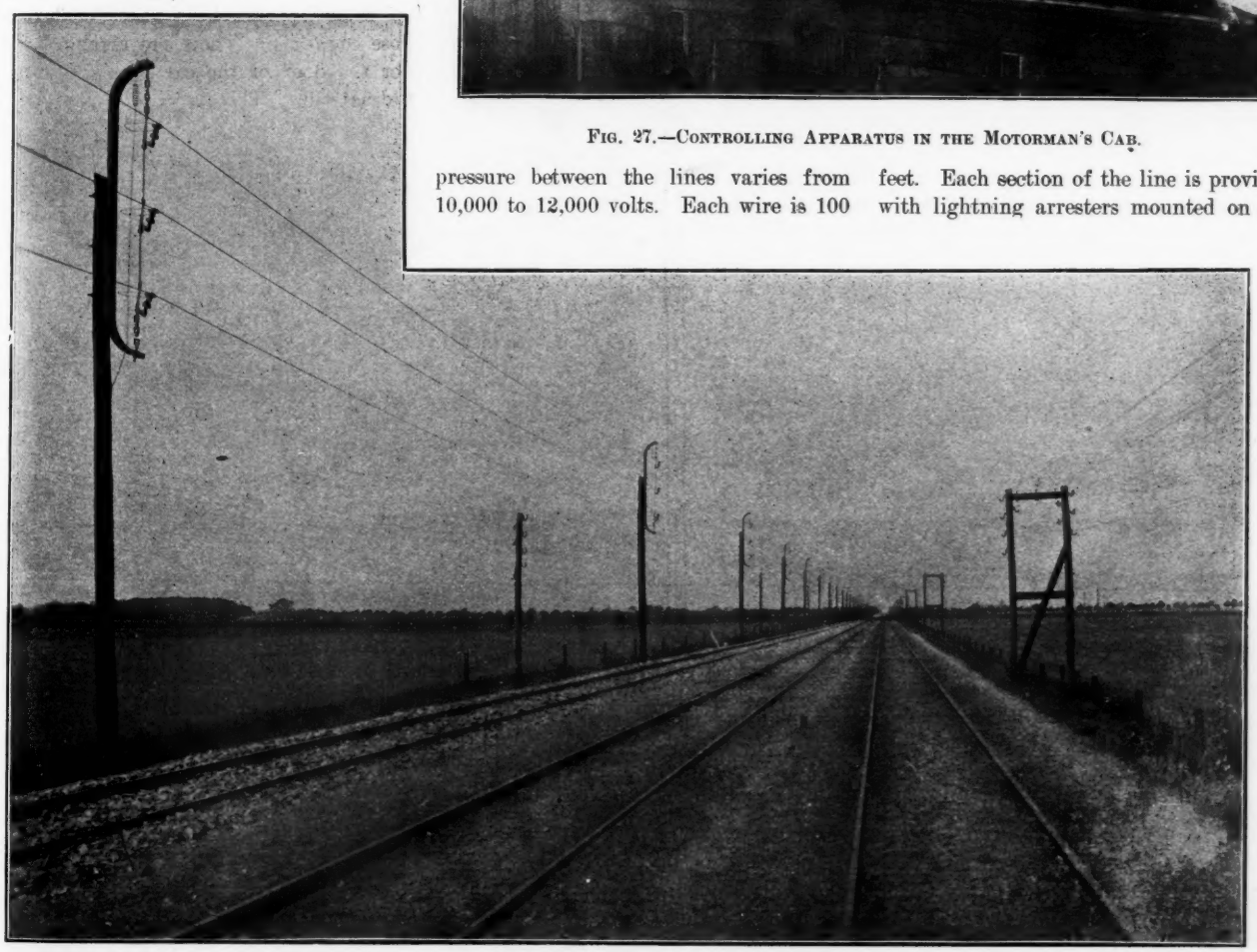


FIG. 28.—ILLUSTRATING TRACK AND TROLLEY LINE.

a copper cable and at every kilometre the rails are also carefully grounded by iron ground-plates. The neutral point of the distribution system is connected with the rails.

The feeder lines connecting Marienfelde with the power station at Oberschönweide consist of four wires, three being the high-tension conductors and one a neutral wire, run on porcelain insulators mounted on wooden poles. In a few places, where the overhead construction is impracticable, they are run underground in cables.

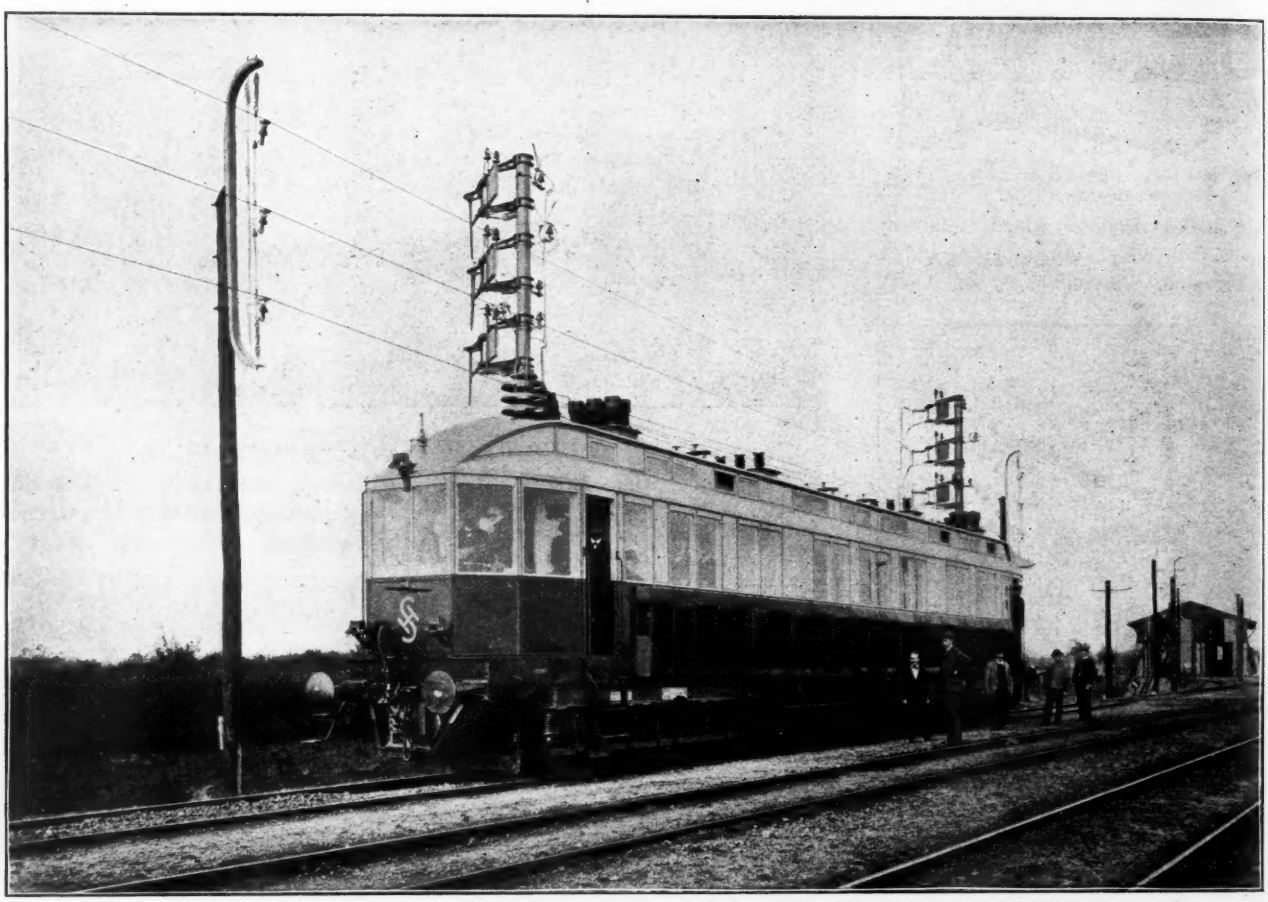


FIG. 29.—THE HIGH-SPEED CAR, SHOWING DETAILS OF TROLLEYS, CONDUCTORS, TRACKS AND GENERAL ARRANGEMENT.

In connecting the feeder line with the trolleys circuit-breakers are used.

OPERATION.

Very careful tests were undertaken after all the apparatus was assembled, the whole having been subjected to pressures up to 15,000 volts. The control and motor mechanism was also tested by running the motors with the car jacked up off the tracks. In running, the only thing necessary to handle is the valve for controlling the motors and the small hand-wheel for operating the starting apparatus. In stopping only one lever has to be handled, this automatically operating the other. The motorman is protected as absolutely as may be, and can not possibly come in contact with any part of the current-carrying apparatus.

The trials on this line were started in September last and have been continued during the intervening months. Two cars were drawn by the locomotive described above, first with a speed of 60, then 100, 120, 140 and 160.25 kilometres per hour (respectively, 37, 62, 75, 87 and 100 miles per hour). These speeds were reached with entire success. They have already given the most valuable opportunity for observing the working of brakes at high speeds, upon the visibility of signals, power absorbed, air-resistance, etc. All of the arrangements, the trolley line, the trolleys themselves, the motors and cars, exhibited entirely successful operation and it is believed that even higher speeds can be attained without the least inconvenience. On the contrary the track, in spite of the excellent condition of the rails, did not seem to be solid enough for speeds more than 160 kilometres an hour and the tests were not forced beyond this final speed of 100 miles per hour on account of its condition.

It may be noted here that no modifications were made in the track for these trials except in putting in extra cross-ties. For further tests heavier rails will be substituted. The present rails weigh about seventy-five pounds to the yard.

The result of these trials marks unquestionably important progress in the field of electric traction and it is not doubted that the German Emperor, who was greatly interested in the formation of the company for experimenting in this direction, and to which he gave the privilege of using the military railway, will hasten the transformation of some important system of traction in his country. The advantages of electric traction are too well known to need discussion here. While perhaps it has not been shown yet that it would be of advantage to utilize it for heavy freight trains, still the extraordinary flexibility which it gives to service of a regular and frequent class at whatever speed may be required, will doubtless show the most favorable economical results in the future.

The Society of Chemical Industry.

A meeting of the Society of Chemical Industry was held at the Chemists' Club, New York city, Friday evening, March 21. Papers were presented by Messrs. A. G. Stillwell, Harrison P. Eddy, A. J. Cohn and George L. Norris.

Electrochemistry and Electrometallurgy.

A Symposium before the American Institute of Electrical Engineers.

(Concluded from last week's issue.)

COLLOIDS—(*Concluded*).

BY W. R. WHITNEY.

It seems probable from the work already done in this part of the field by various investigators that a small part of the electrolyte which causes the precipitation or coagulation of the recognized suspension is always carried with it into the precipitate. This is usually very small, but a further knowledge of its magnitude in different cases is very much to be desired. Does such an attendant phenomenon occur in the precipitations of nature referred to? The presence of inorganic matter in all of nature's coagulated colloidal material justifies such an assumption of analogy. Nowhere do we find nature's organic products "ash-free," as would be the case if they were the pure colloid.

What function does the electrolyte play in this coagulation? Here speculation is rife. Thus far there seems to be evidence that the coagulation corresponds to the conception of a neutralization of the charges of the suspended particles by oppositely charged parts of the electrolyte.

Many of the facts thus far obtained as the result of experiment can be made to seem consistent on the assumption of already existing hypotheses, and the value of any coordination of these hypotheses must serve as the excuse for their use. We are forced to recognize that the presence of the electrolyte causes the coagulation or precipitation. Bredig assumes that this is brought about by the stress in the dielectric (*i. e.*, the solvent) caused by the presence of the electrostatically charged ions. This would be a natural consequence if the ions are thus charged. Other investigators assume that the electrostatic charges of the particles of the suspension are neutralized by oppositely charged ions of the electrolyte. These charges once neutralized, the forces keeping the particles apart have disappeared and precipitation occurs. This latter seems to accord with many facts, and is a working hypothesis.

Whether a colloid is made up of positively or negatively charged particles may be learned by observing the direction of its motion between electrodes. It has been found that the coagulating power of a certain salt on a given suspension of a negative colloid is practically a function of the concentration of the positive ion only, and, furthermore, that this ion is retained, in some cases at least, by the precipitated colloid, while the negative ion is not. The precipitating power seems practically independent of the nature of the positive ion except that it varies with its valence. There is only one way in which it seems at all possible that this can occur, namely, that the precipitate produced shall contain the hydrate of the metal ion, and the remaining or clarified solution be correspondingly acid. This has been found to be the case in the single colloid which has been thus quantitatively examined.

Furthermore, the coagulating powers of different electrolytes, as, for example, potassium, barium or ferric chloride, where the valence of the metal differs, and where, according to the hypothesis of statically charged ions, the charges differ, are in that numerical relationship which might be expected from the assumption of a neutralization of charges of opposite sign in the coagulation. This calculation was carried out by Whetham practically as follows:

Evidently equal charges should be available from $2n$ triad ions, $3n$ diads and $6n$ monads, where n is a whole number. Probability of contact between colloid and ion should be proportional to the concentration C of the ion or equal to AC, where A is a constant. The probability of two such ions being together is $\overline{AC}^{2}$ and of "n" ions $\overline{AC}^{n}$. For equal coagulative power of ions of different valences $\overline{AC_3}^{2n} = \overline{AC_2}^{3n} = \overline{AC_4}^{6n} = B$ (a constant). The concentration of trivalent, bivalent and univalent ions, respectively, being C_3, C_2, C_1, hence $C_1 : C_2 : C_3 = I : \sqrt[4n]{B} : \sqrt[4n]{B} = I : K : \sqrt[2]{K}$, where K is a constant. That is, from the known coagulating powers of univalent and bivalent ions, that of ions of higher valencies could be calculated. Experimental determinations of relative coagulating powers for potassium, barium and aluminum have given the ratio of 1 : 32 : 1,020, approximately, which agrees with the calculation.

This means that a given negative colloid will be equally affected or coagulated by solutions of sodium, potassium and ammonium salts of molecularly equivalent concentration, while barium, calcium, strontium, etc., or bivalent elements, will be much more active coagulants, approximately equal among themselves; and trivalent elements, such as iron, chromium and aluminum, will be most powerful. The ratios of the coagulative powers of these groups, as found by experiment, namely, 1 : 30 : 1,000, also seem to preclude the possibility of simple chemical reactions.

While it is true that most insoluble matter is negatively charged as compared with water, there are some suspensions which are positively charged, and here it is found that the concentration of the negative ion of the electrolyte, instead of the positive, is the factor determining the coagulation. In other words, if chlorine be the ion under consideration, the precipitating powers of all chlorides on this positive colloid will be the same when the concentration of the dissociated chlorine is the same.

If colloidal solutions or suspensions are made up of statically charged particles, the fact that they are precipitated by electrolytes, together with the quantitative relationships of this precipitation and the seeming probability that a part of the electrolyte is rendered insoluble in the process, make the connection of this phenomenon with the electrolytic dissociation theory a most natural one. I personally feel that, conversely, speculation as to possible connections between electrical or electrolytic phenomena in the living plant or animal and the little-understood reactions occurring there is well warranted. Such hypotheses as have been advanced by Professors Loeb and Mathews, of Chicago University, to explain, among other things, the actions of the nerves and the relationship between nerve phenomena and electrical excitation certainly lead to renewed attack on old problems and the temporary harm of such a conception, even if later shown to be mechanically imperfect, is overbalanced by the numberless additional facts brought to light.

ELECTROLYTIC RECOVERY OF COPPER FROM LOW-GRADE ORES.

BY N. S. KEITH.

Low-grade cupriferous rocks are those which contain such small amounts of copper per unit (say a ton) of weight that a large number of such units must be treated daily to make a commercial profit.

Where labor, fuel, power, supplies and such requisites are cheap, and the market for the product is near at hand, the percentage of the yield of copper may evidently be less than in cases where expenses are higher, as in regions remote from civilization and the market.

Low-grade ores may, then, also be defined as those which contain from one and one-half to five per cent of copper, with favorable conditions in inverse proportion.

Some low-grade cupriferous rocks may carry enough gold or silver, or both, to make them valuable for treatment for recovery of all of the metals when the amount of copper recoverable alone would be unremunerative.

There are two methods, the dry and the wet, by which low-grade cupriferous rocks are treated. In this paper I am to consider but one—the wet. There are varieties of the wet method, but I will confine myself to the one variety in which electrolysis is used to effect the final deposition of the copper obtained in solution during the procedure.

There are many varieties of copper ores which may be treated metallurgically by the wet method, but with many variations which the limits of this paper will not permit of consideration.

A rehearsal of the conditions and considerations applied by the author in the planning and erecting of works for the electrolytic method of recovering copper from the ores of a mine a few miles from New York city may be interesting and instructive.

These are the conditions:

The mine was worked intermittently from 1715 up to 1863; sometimes at a profit and sometimes at a loss, but always by methods crude and antiquated compared with those at present pursued in the art. All of the rock contains some copper, but there were, and are, in it streaks, seams, veins, etc., which carry values up to seventy per cent of copper, though these serve to leaven the whole to the value of about two per cent, or forty pounds of copper to the ton; thus making millions of tons of low-grade copper-bearing rock which may, by scientific mining and milling, be profitably worked.

Prior to 1863 the miners sunk shafts and ran drifts in this rock without any apparent system, in the evident search for the richer ore seams, streaks and veins which I have mentioned. Whether they made or lost money depended upon their luck in finding more or less of these richer portions.

Modern methods frequently warrant the working of nearly or quite all of such rock containing disseminated rich ores rather than by picking out only the richer portions solely for treatment, and throwing the major parts onto the waste dump pile.

The ores impregnating the rock are chalcocite (copper glance), Cu_2S (copper 79.8 per cent, sulphur 20.2 per cent); malachite (green copper carbonate) (copper 62 per cent; azurite (blue copper carbonate) (copper 61 per cent); cuprite (cuprous oxide) Cu_2O (copper 88 per cent), and some oxides of iron.

The rocks, called by miners "gangue," in which these ores are found are of several kinds, mainly sandstone of the Triassic period; trap, cutting the sandstone in all directions and frequently overlying it; breccia, indurated clays and shales. I will not attempt to theorize as to the origin of the copper contents of these rocks. They lie in a bed having a thickness varying from twenty to sixty feet, dipping westerly at an angle of about nine degrees from the horizontal. The mining is cheaply done, and the rock is dumped directly into the mill from the ore skip, which is brought from the mine by means of an electric hoist and runs back into the mine by gravity. The scope of this paper does not admit of the consideration of the mining methods.

The problem for the metallurgist was to obtain the copper contents of the rocks after they were landed in the mill, in the cheapest and most expeditious manner. This was decided to be by dissolving the copper and depositing it from the solution by electrolysis.

In order to prepare the rock for treatment by solvents it is passed through the following operations:

As the rock is raised up the incline from the mine by means of a "skip," it is automatically dumped into the hopper of a Gates type of crusher, which breaks the rock to the size of about three-quarters of an inch to one-inch cubes, and smaller. Three minutes suffice for this operation on one skip load of one and one-half to two tons.

All of the machines of the plant are run by means of motors obtaining their current from a direct-current generator of 300 kilowatts at 240 volts, direct-connected to a tandem compound condensing engine. This generator also supplies the current for the electrolytic vats.

The broken rock falls from the crusher into a steel bin holding about 400 tons. This steel bin has its bottom inclined so that it may be emptied by gravity through gates on the side at the lower edge near the bottom.

The rock coming from the mine is damp, containing about eight to ten per cent of water. Of necessity it has to be dried before further reduction in size. This is accomplished by forcing heated air or furnace gases through the body of ore lying in the bin. This has been found to be an economical and effective way of drying.

From the bin gates the rock is moved in a constantly flowing stream, by means of a feeder belt, to a set of crushing rolls, which further reduces the size of the pieces of rock to that of peas or beans, and smaller, even to sand and dust. This is then elevated and caused to run by gravity over inclined wire-cloth sieves called "separators," which separate the sand and dust for the next step of treatment. The coarser pieces which do not pass through the meshes of the sieve run into pulverizing machines, which reduce them to the size at which they pass through the sieve when again run over the separators. The rock is thus crushed, ground and pulverized so that it will all pass through the meshes of a No. 30 wire cloth having 900 holes to the square inch.

This degree of comminution is necessary in order that the particles of copper ores impregnating the rock may be set free, or exposed, so that they may be acted upon by the agents used in the next step of the operation. These steps are roasting and lixiviation.

While the oxides and carbonates are readily soluble in dilute acids, the cuprous sulphide, or chalcocite, is not. Even strong and boiling sulphuric, or hydrochloric, acid will not dissolve it. Boiling, or hot, nitric acid will. But the use of nitric acid is not admissible for other reasons than its expense.

Therefore, it is necessary to decompose the chalcocite by expelling its sulphur and oxidizing its copper. This can best be done by roasting. The roasting takes place continuously, as the rock comes from the pulverizers, in a mechanical furnace having a hearth 200 feet long by 10 feet wide, and fired by coal in seven fireplaces arranged along its sides. Rabbles, or rakes, are caused to continuously travel from end to end of the furnace, in their course stirring the powdered rock, exposing con-

tinually renewed surfaces to the action of heat and atmospheric oxygen, and moving it to the discharge end. From the discharge end the roasted rock is conveyed to the lixiviation or leaching tanks. The capacity of this furnace is about 125 tons of powdered rock per day of twenty-four hours.

The reactions which take place in the furnace are these: The carbonates of copper are decomposed, setting free CO_2, and their copper contents oxidized to CuO; the chalcocite is decomposed, the sulphur set free and oxidized, and its copper contents oxidized to CuO; the ferrous carbonates are decomposed and the oxides are further oxidized, which makes them less soluble in dilute acids. The roasting of chalcocite, Cu_2S, does not produce any $CuSO_4$ as in roasting other copper sulphides, for instance chalcopyrite, containing CuS. There is not sulphur enough in Cu_2S to supply the equivalent of S to form $CuSO_4$. The sulphur of the chalcocite either escapes with the gases of the furnace, or unites as SO_3 with the earthy alkaline constituent of the rock, lime, as calcium sulphate.

There is some calcium carbonate, as calcite, in the rock; say about one-half of one per cent. In order to economize in the use of acid it is necessary to mix with the rock as it passes into the furnace some powdered sulphide ores preferably carrying at least a small percentage of copper, which copper is recovered in the subsequent steps of the process. This is an economic feature, because such ores are cheaply purchased and serve the double purpose of supplying sulphur to be oxidized and unite with the lime as $CaSO_4$, and a means of obtaining their copper contents. Sulphur may be used in the same manner for the purpose of neutralizing or counteracting the lime. When sulphide or sulphur is used in the roasting much of the copper is sulphated, and as $CuSO_4$ is readily dissolved in water.

The practical result of the roasting is a powdered rock having disseminated therein some $CuSO_4$, some CuO, and some FeO and Fe_2O_3; the last of which list is practically insoluble in the acid used.

To extract the copper contents the solvent used is primarily $H_2SO_4 + x\ H_2O$. HCl may be used as a solvent, but there is a difficulty in obtaining anodes which will not seriously deteriorate in the subsequent electrolysis. The percentage of H_2SO_4 is determined by the amount of copper to be dissolved by a definite amount of solvent. The amount of H_2SO_4 may vary from five per cent to fifteen per cent of the water of the solution.

As will be described further on, after the primary use of the solvent ($H_2SO_4 + x\ H_2O$), another solvent of the copper oxide takes part in the action, namely, $Fe_2(SO_4)_3$, ferric sulphate.

From the roasting surface the rock is conveyed to one of four leaching tanks, filling them in succession. Each tank is cylindrical, thirty feet in diameter and six feet high, inside measurements. They each hold 125 to 150 tons of the powdered and roasted rock. The rock is put in hot as it comes from the furnace.

In the bottom of each tank there is a filter bed of coarsely crushed rock, covered with canvas which is calked tightly around the edges and around the outlets through which the powder is washed after the extraction of its copper contents.

From the centre of the bottom of each tank, under the filter bed, a pipe, with a stop-cock, serves through which to draw off the solvent to the electrolytic cells.

During the filling of each tank a suitable amount of the solvent is admitted to moisten the rock, and finally, when filled to within about a foot of the top, the whole is flooded by the solvent to the depth of a few inches above the bed of powdered rock.

The solvent begins to run from the bottom of the first filled leaching tank as soon as filled, running through the filter bottom in a stream of perfectly clear greenish blue liquid. From time to time as the liquid on the top is lowered to the surface of the rock a few inches in depth more of the solvent, drawn from the "stock-solution tank," is run in.

The first solvent run in during the filling of the tank takes up nearly all of the copper, and runs out at the bottom fully saturated with $CuSO_4$. As the fresh additions of solvent pass through the bed of rock they carry decreasing quantities of copper until all of it has been taken up, and the solvent running out shows little or no more by assay than does the solvent run in.

But, meantime, tanks Nos. 2, 3 and 4 have been filled, and a like solvent action takes place in them. Then, in order to have a solution of nearly uniform value in copper to electrolyze, the richer liquors from No. 2 are run out simultaneously with the poorer from No. 1. This method is kept up in regular succession with the other tanks.

As soon as the rock in No. 1 has had its copper contents dissolved by the solvent the outlet is opened and the solution runs into the deposition vats, and as the quantity of copper in the solvent from this tank decreases in amount the outlet of No. 2 is opened to allow a flow of strong solution to mix with that from No. 1, and so on with Nos. 3 and 4, and then from a new charge in No. 1, and so on, in a continuous cycle of operation. This procedure is for the purpose of supplying the deposition vats with a steady stream of lixiviate having constant percentage of copper.

The tanks are emptied by opening passageways through the filter bed and bottom of each tank, and turning a forcible stream of water, pumped for the purpose, against the depleted powder, then called "tailings," thus washing them out, after the manner called "hydraulicking" in some kinds of gold-mining.

The deposition vats are rectangular boxes of wood protected from the action of the lixiviate, now the electrolyte, by a suitable lining. They are arranged so that the electrolyte flows from No. 1 through Nos. 2, 3, 4, *et seq.*, and finally out of No. 128, depleted of its copper, into a large tank, called the "sump," from whence it is pumped up into the "stock tank" for re-use.

These deposition vats are so set, at differing elevations above the floor of the building, that the electrolyte runs by gravity from one to the next, and so on through the series to the end, through troughs, or spouts, between their ends, with this exception: As the vats are arranged in six rows, and one end of each row is at a greater elevation than the end next to it of the preceding row, it is necessary to raise the electrolyte from the one row to the next at those points. This is done by means of air-lift pumps, which are easily managed.

The electrical connections are as follows: The electrodes in each vat are connected in multiple; and the several vats of electrodes are connected in a series of 128; exactly, so far, as is the case in large storage batteries.

But for the purpose of ensuring a retrogressive decrease of density of current at the electrodes of each vat, after the first of the series, the number of electrodes is increased progressively from the first to the last of the series. The amperes of current are the same in each vat of the series, but the current density is less and less in decremental order from the first to the last of the series, to compensate for the decrease of copper in the electrolyte in its course through the vats. Thus the density of current may be fifteen to twenty amperes per square foot of cathode surface with a six per cent copper solution, and three amperes per square foot with a 0.5 per cent solution; provided proper circula-

tion and sufficiently rapid movement of the electrolyte be kept up between the anode and cathode surfaces.

The evolution of free oxygen at the anodes keeps up a continual mixing movement of the electrolyte, in addition to the motion due to the flow through the vats.

During electrolysis there is a counter-electro-motive force of 1.6 volts in each vat of the series, due to the difference of energy of combination between the materials on the surfaces of the anodes and cathodes, respectively, and the constituents of the electrolyte. The generator is operated at approximately 240 volts; which gives $240 \div 128 = 1.87$ per cell. The voltage per cell required is $1.87 - 1.60 = 0.27$ volt for resistance of conductors, etc.

The density of current must not exceed in any vat the limit beyond that required for the deposition of reguline copper.

Primarily both the anodes and cathodes are of sheet lead. But under the electrolytic action the anodes become coated with PbO_2, and the cathodes with copper. As soon as the copper deposit reaches the thickness of thin cardboard it is stripped off each lead cathode, which is then replaced in its cell, and the two copper sheets thus produced have suitable connections riveted to them, and they are then rehung as cathodes in some of the vats, where they remain a sufficient length of time to receive a deposit of copper to the thickness needful for the market.

The author has tested anodes of carbon, both such as are used for battery plates and the Acheson graphite electrodes. There is much less oxidation and disintegration with the latter, but still too much for economy. There are also some other difficulties incident to the use of carbon. Under proper treatment the lead anodes do not sulphate, and the formation of PbO_2 is merely superficial.

A certain proportion of the lead cathode plates are specially used for the purpose, as above, of producing the thin copper cathodes, it being a handier and a cheaper method than providing rolled thin copper sheets for the purpose.

The lixiviate running from the leaching tanks into the deposition vats consists of a solution in water of sulphuric acid, cupric sulphate and ferrous sulphate, expressed symbolically as follows:

$$x\ H_2SO_4 + 2\ CuSO_4 + 4\ FeSO_4.$$

The electrolytic action deposits the copper on the cathodes, perhaps by secondary action, without the evolution of hydrogen, but with the setting free at the anode of oxygen. But some of the oxygen and acid are appropriated by the ferrous sulphate, thus becoming ferric sulphate. When there is enough ferrous sulphate present at the anode no free oxygen is evolved, but is appropriated by the ferrous sulphate to form basic ferric oxide which unites with the sulphuric acid to form normal ferric sulphate, as per this equation:

$$x\ H_2SO_4 + 2\ CuSO_4 + 4\ FeSO_4 = 2\ Cu + 2\ Fe_2(SO_4)_3 + x\ H\ SO_4.$$

Taking the latter half of the above equation for consideration, the two parts of copper are deposited on the cathodes and the solution of ferric sulphate and sulphuric acid runs to the sump tank, from whence it is raised to the stock tank, and from there is used on subsequent lots of powdered and roasted rock in the leaching tanks. While the starting of the plant involved the use of a solution of sulphuric acid for the solvent, all subsequent solvent actions take place in the presence of ferric sulphate and ferrous sulphate as well.

Now, ferric sulphate solutions are energetic solvents of metallic copper, oxides of copper, and, to a limited extent, of some sulphides of copper, with reduction from ferric to ferrous solutions and ferric oxide. Take metallic copper and we have this equation:

$$Cu + Fe_2(SO_4)_3 = CuSO_4 + 2\ FeSO_4.$$

Take cupric oxide:

$$3\ CuO + Fe_2(SO_4)_3 = 3\ CuSO_4 + Fe_2O_3.$$

This latter equation shows that ferric oxide (Fe_2O) is freed by the solvent action in the leaching tank, and remains there undissolved, thus continually purifying the solution of iron.

The roasting process may sometimes fail to completely oxidize the Cu_2S; if so, then the following equation expresses a further action:

$$Cu_2S + 2\ Fe(SO_4)_3 = 2\ CuSO_4 + 4\ FeSO_4 + S.$$

It has been claimed that cupric oxide is dissolved by a solution of ferrous sulphate by double analysis and synthesis, per this equation:

$$CuO + 2\ FeSO_4 + H_2O = CuSO_4 + (Fe_2O_3 + SO_3) + H_2.$$

The sulphuric acid dissolves some cupric oxide as per this equation:

$$CuO + H_2SO_4 = CuSO_4 + H_2O.$$

It will be seen that all of the reactions result in the production of cupric sulphate in the lixiviate which is to be electrolyzed. There is no deposition of iron on the cathode, even though its sulphate salts are present in the electrolyte in great excess, say near to saturation of the solution.

Unfortunately, the expenses of the operation can not now be stated, because not yet obtainable. Just as the plant was starting financial difficulties intervened and caused a stoppage. Enough had, however, been done, in an experimental way, to make positive all of the principles of the process; and that, probably, the expenses of mining and metallurgical treatment need not exceed two and one-half dollars per ton. It is probable that work will soon be resumed.

Electrical Progress in British Honduras.

United States Consul W. L. Avery writes from Belize that an appropriation of $10,000 has been voted, the consent of the home government granted, the contract signed and work begun on the first telegraph line in this colony.

This line will extend from Belize to the Rio Hondo, a distance of 100 miles, and offices will be established at Belize, Corozal, Orange Walk and the Hondo River, and at the last-mentioned place business will be transferred to the overland line through Mexico, and communication with the world will be completed.

Though Belize is only 850 miles from New Orleans, it has never had the benefit of telegraphic service, and a message from Europe or the United States, if forwarded on a given Thursday, could not be delivered here until ten days later, and any message would take at least four days, being sent from New Orleans by mail steamer.

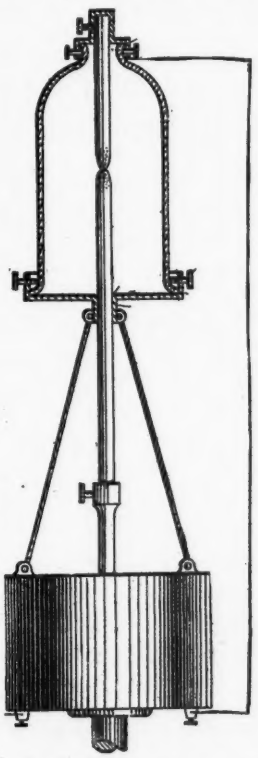
It is proposed that a telephone service be established at each of the offices, and in order that one wire may serve both purposes, the circuit will be shut off for two hours each day, giving ample time for local business. As three months are all that are required to build the line, it may be assumed that by May 1, 1902, Belize will be in closer touch with the rest of the world.

A bill is now before the colonial councils extending authority to the district board of Belize to contract for the establishment of an electric-light plant in this town, and granting the contractor the privilege of lighting public and private houses. The bill will undoubtedly become a law, and the oil lamps of this town will soon be a thing of the past.

The equipment for the telegraph line has been ordered principally from New York, and the material for the lighting plant will also be ordered from the United States.

Electrical Patents

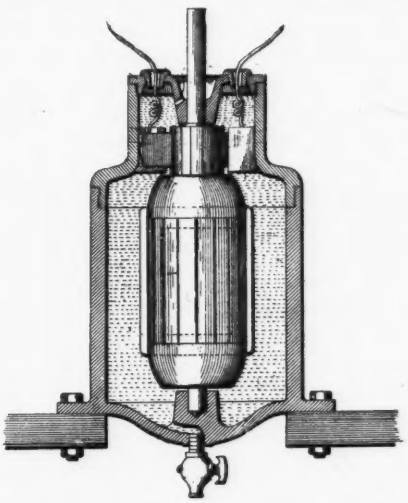
An improvement has just been made in the means for supporting the globes in that class of electric arc lamps wherein the carbons are burned in a partial vacuum. The improvement was devised by Mr. Moses S. Okum, of New York, N. Y., his object being to provide a support which will yield laterally without in any manner affecting the feeding of the carbon. The arc-enclosing globe may be of any well-known form, having the usual upper opening through which the upper carbon feeds, the lower carbon being seated in the lower portion of the globe.



Improved Electric Arc Lamp.

Hangers are pivotally suspended from the casing of the lamp and their lower ends are pivotally secured in any suitable manner to the globe. In one form the inventor shows a cross-bar that is pivoted to the support for the lower carbon, the hangers being fastened to the ends of this cross-bar. In another form the hangers are pivoted directly to the removable top of the globe. The patent obtained on this improvement covers these various forms of modifications.

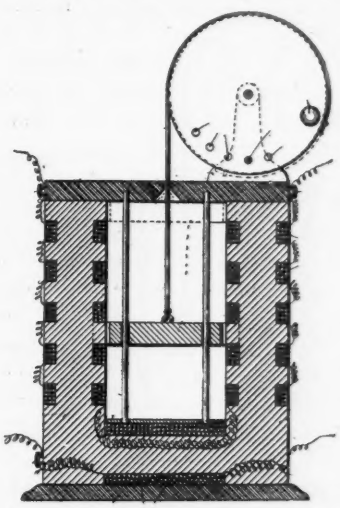
An important improvement has just been made in that class of electric motors that are submerged at the stern of a small boat, and carry a propeller for driving such boat. The invention is the work of Mr. Tracy B. Hatch, of Menomonee, Wis., who has sold the patent obtained thereon to the Submerged Electric Motor Company, also of Menomonee. Hitherto in this class of electric motors it has been usual to enclose the motor in a moisture-excluding casing and provide a moisture-excluding stuffing box about the motor shaft where it extends to the outside of the casing. To properly answer its purpose, the stuffing box must necessarily fit



Improved Submerged Electric Motor.

very closely about the shaft, and in these small motors the frictional resistance thus created greatly diminishes the power. In the improvement a vessel is provided which in itself forms the motor field and is provided with internal field magnets and bearings for an armature shaft, all the working parts of the motor being confined within the vessel; this vessel is then filled with a fluid-sealing substance of low conductivity such as hydrocarbon oil, and this fluid operates instead of a stuffing box to exclude the water without the necessity of a tightly packed stuffing box. The oil also exerts a cooling influence upon the motor windings and will operate to prevent sparking between the commutator and its brushes.

Mr. Frederick R. M. Cutcheon, of St. Paul, Minn., has just patented an improved amperage or current regulator for series arc-lamp systems. He provides a substantially U-shaped laminated iron core which is supported on an insulated base with its prongs or arms uppermost, the free ends being connected by an insulating plate such as a marble slab. The primary coil is wound on the yoke of the core and extends to suitable binding-posts to which the primary leads are connected. The secondary coil is wound on both prongs or arms of the core, being formed of spaced sections that are connected in series. This secondary coil is connected to binding-posts that are located on the slab or plate, the leads of the secondary circuit being attached to the binding-post. A soft iron bar or armature is movably located in the field of the secondary coil, and is therefore slidably mounted on brass rods located between the arm or prongs of the core. This bar is adjusted by suitable mechanism, preferably in the form of a sheaf pulley, journaled upon the upper slab, the pulley and armature being connected by means of a suitable flexible cord. The operation of the device is substantially as follows: There are provided as many sections of the secondary coil as there are lamps in the circuit, and assuming that each lamp will require seventy-four volts and seven amperes, and that each section of the secondary coil is capa-



Amperage or Current Regulator.

ble of inducing a current of thirty-seven volts and seven amperes, it will be evident that under these conditions, since the horizontal opposite sections of the secondary coil are cut into and out of action in pairs by the armature, that this armature can be adjusted so as to cut into action below the same as many pairs of coil sections as there are lamps thrown into action. When thus adjusted, the armature short-circuits the magnetic field of the sections above the same, while the sections below will be sufficient to run the lamps that are in action.

Manufacturers at Indianapolis.

The seventh annual convention of the National Association of Manufacturers will be held in Indianapolis, Ind., April 15, 16 and 17. Local arrangements for the convention are being made by a committee of Indianapolis business men, under the leadership of Mr. D. N. Parry, who has been for many years a member of the executive committee of the association.

Notes from Great Britain.

(By Our Special Correspondent.)

THE success or otherwise of Marconi's wireless transmission across the Atlantic has stirred Sir John Wolfe Barry, when presiding at the fifty-ninth half-yearly meeting of the Eastern Telegraph Company, "to say a word" on the matter, presumably with the object of edifying and pacifying those shareholders in such undertakings who may fear for their investments. Incidentally he mentioned that the Eastern company selected Professor Oliver Lodge and Sir W. H. Preece to prepare independent reports, for submission to the shareholders, upon the present possibility of wireless telegraphy as a competitor to the deep-sea cable. These reports, he said, pointed out that wireless telegraphy as now understood labored under inherent and inseparable disadvantages compared with cable transmission, which must prevent it, even over short distances, from being anything more than an inferior mode of transmission. Dr. Lodge was of the opinion that submarine cables would for a long time be preeminent for long-distance telegraphy, while Sir W. H. Preece was very clearly of opinion that submarine cable enterprise had nothing to fear, in a commercial sense, from the competition of etheric telegraphy.

Some time ago reference was made in these notes to the fact that the Board of Trade had been asked to determine certain queries by the London Chamber of Commerce in respect of the extra high pressures likely to become universal owing to the increasing number of "bulk" supply schemes now being formed. From the reply of the Board, it would appear that for pressures over 3,000 volts no standard set of rules apply. Further, it is stated—and will probably prove gratifying to some—that no general limit of pressure has ever been fixed nor any general absolute limitation of the size of mains. From all this it is quite evident that each particular scheme is treated upon its own basis, which is as it should be.

Very smartly has the Liverpool Overhead Railway Company recovered from the shock administered by the recent fatal fire on its railway. The official inspection of the reconstructed station has been made at the Dingle end of the line, and general satisfaction was expressed at the improvements. Incombustible material only has been utilized throughout and a fire alarm system has been installed, and, generally speaking, a disaster similar to the one which happened last December is now almost an impossibility. At any rate, that is the opinion of the company's engineer.

An interesting installation over here to Americans generally should be the experimental line of tramway erected by the Lorain Steel Company on its surface contact system by an arrangement with the Wolverhampton Corporation. The corporation has been granted a licence to test the line for twelve months by the Board of Trade. I have before mentioned that the steel company is working this track themselves for the period of a year, after which time it will be handed over to the corporation if the thing is satisfactory. The experimental line, which is now carrying passengers, is one mile long and of three feet six inches gauge. Colonel Yorke and Mr. Trotter recently inspected the line on behalf of the Board of Trade, and the chief points of criticism were the "Providence" fenders on the cars, which the former gentleman strongly urged should be replaced by something better, and the possibility of shock to horses and pedestrians should the steeds fail to perform their proper functions. Mr. Trotter, after a careful examination of the details of the steeds and connection, considers accidents only a remote possibility.

The Kingsland Surface Contact System Syndicate has also entered into a conditional agreement with a small local authority in Devonshire to construct surface contact tramways and also supply electrical energy for lighting. This system was described in the ELECTRICAL REVIEW nearly twelve months ago.

The growth of the electrical supply business in Great Britain is well exemplified by some recent happenings in connection with new, and extensions to existing, power-houses. Only a short time ago the Manchester Corporation laid the foundation of a large new power-house; very shortly the City of London Electric Lighting Company will hold a press inspection of a fine installation of continuous-current machinery, additional to its old alternating-current plant, and the Bristol Corporation has opened a new works on the banks of the River Avon, and the anticipations of the Electric Lighting Committee and its advisers are reflected in the enormous amount of extension room available on the site of the new station. A more ideal spot for an electricity generating station is probably not easily found, for it is bounded by a colliery, a canal and a railway. The chief distinguishing feature of the station is an extensive and complete "Hunt" coal-conveying plant erected by Messrs. Babcox & Wilcox as licencees to the American company. Three 745-kilowatt Siemens alternators are driven by Willans engines, and there are also continuous-current Siemens-Willans sets for power.

A good deal of mono-rail talk is flying about at the moment. In opposition to the promoters of the proposed London to Brighton express electric railway, partly in tunnel and partly on the surface, Mr. Behr has made a proposition to the owners of the present steam railway company running to Brighton that he should construct or practically convert their line into a mono-rail, and says he could do it for almost millions cheaper than the aforesaid promoters. Then a proposal has been made to construct such a line between Glasgow and Edinburgh, which would cover the forty-nine miles at a rate of 117 miles an hour.

Still a great dearth of electrical motor vehicles exists in Great Britain. A motor car show has just been held at the Crystal Palace, and the sum total of firms exhibiting electrically driven vehicles was two.

London, March 8.

Electrolytic Bleaching.

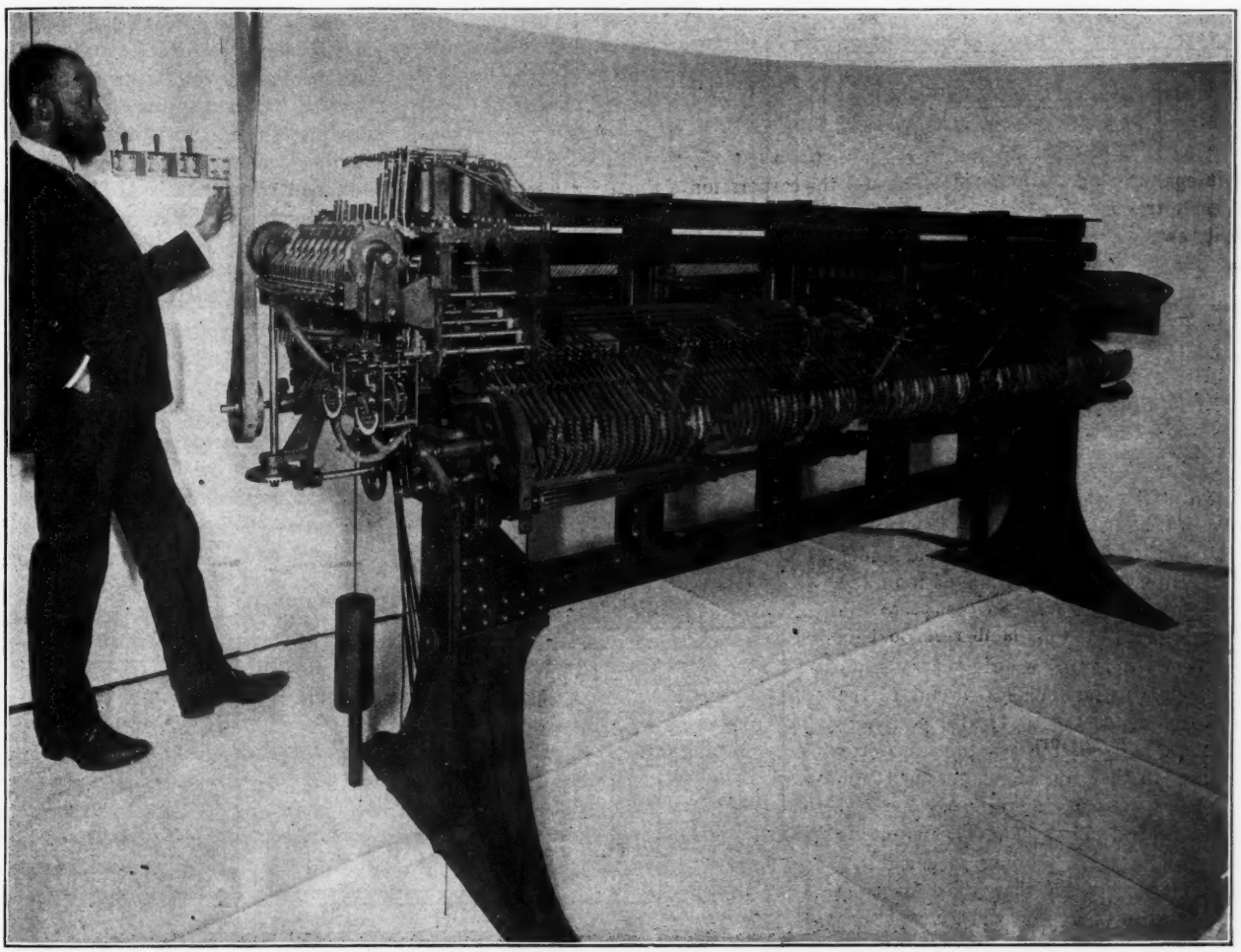
A rather heated controversy, says the London *Electrical Times,* has been for some time proceeding in *L'Electrochemie* between V. Engelhardt and F. Œttel on the respective merits of the Kellner and the Hass and Œttel machines for the production of bleaching liquor. Both disputants claim to have long ago shown that a high-current density, a low temperature and a strong concentration of salt, notably augment the yield of chlorine. But while both apparatus are capable of fulfilling the conditions, the Kellner usually works with a ten per cent salt solution and a C. D. of 7,000 to 10,000 amperes per square metre, the Œttel with seventeen per cent salt and 1,000 amperes C. D. Tables of efficiencies are given which lead to contradictory conclusions, but, as M. Œttel remarks, *la pratique en décidera.*

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

The Faller System of Automatic Telephony.

There has been on exhibition in New York city for some time a highly ingenious piece of apparatus, the invention of Mr. E. A. Faller, of Baltimore, for automatic telephony. The accompanying illustrations give a view of the central exchange equipment for one hundred lines, together with a number of details of the system.



THE FALLER AUTOMATIC TELEPHONE EXCHANGE APPARATUS FOR 100 LINES.

The subject of automatic telephony is one that has exercised in no small degree the talents of inventors. Shortly after the introduction of the central exchange as a feature of telephone exploitation the increasing size and complexity of such exchanges, and the necessarily accurate and arduous work devolving upon operators, suggested the probability of devising some form of automatic apparatus which would enable any subscriber connected with such an exchange himself to select the line of the person to whom he wished to speak, thus eliminating both the expense and the uncertainty attendant upon manual operation. A considerable number of systems have already been devised, but the new system described below possesses characteristics which make it in many respects different from all the others that have yet been brought forward.

In the Faller system the functions of the operator are performed by a mechanism which, in effect, moves the equivalents of the plugs and cords of an ordinary transfer switchboard. All the lines entering a station end in similar devices and the functions of the mechanical operator, as it justly may be called, are to connect these terminals with one another in the desired way and automatically to disconnect them when conversation is finished. The apparatus employed uses external power, the small amount necessary being supplied by a small electric or other motor, and dispenses almost entirely with electromagnets, solenoids and other devices employing magnetic power for moving the various parts of the system. Fig. 1 is an illustration of the circuits of a subscriber's outfit, while Fig. 2 represents the central exchange circuits. The method of calling is to move numbered dials, contained in a small cast-iron box attached either to the telephone or to the wall near it, until the proper numbers show upon them. Moving a key then permits the call to go in, whenever the central office mechanism is ready to receive it. In the sending instrument arranged for 100 subscribers' exchanges there are two dials, each numbered respectively

from 0 to 9, the numbers upon one dial comprising the units and those upon the other the tens of the number desired by

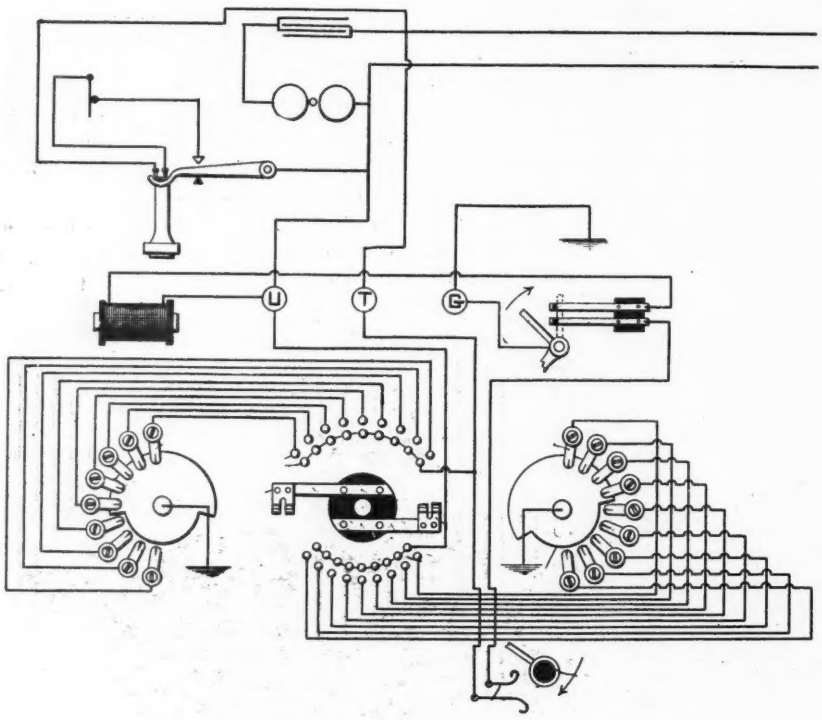


FIG. 1.—AUTOMATIC EXCHANGE APPARATUS—SUBSCRIBER'S CIRCUITS.

the calling subscribers. These dials are shown at the right and left of the lower part of Fig. 1.

Projecting from the front of the sender is a calling-knob, consisting of a milled brass head which may be turned to the right, where it automatically stops. This operation winds up the spring of the sending apparatus, and makes several of the necessary connections. It also positively locks all parts of the sending apparatus against further interference, until the call has been sent and properly received at the central office. The various operations necessary in sending in a call are thus interlocked so that they must be performed in their proper order, and once performed the arrangement can not be disturbed until the call is duly recorded upon the central exchange apparatus. It is unnecessary here to describe the ingenious means used for effecting this interlocking.

Proceeding now to the description of the exchange apparatus: Each subscriber's line, consisting of two wires, is connected at the central exchange to two parallel rods, insulated from the rest of the machine and carrying a carriage mounted so as to travel on the rods as may be desired. This carriage carries the subscriber's terminal springs, which are insulated from each other, but each of which is in electrical contact with one of the rods. These springs are adapted to pass by and to make contact with a series of conductors, consisting of bars laid in a grill at right angles to the rods mentioned above. All of these rods and bars and the other conductors in the machine are of such dimensions as to have no appreciable resistance. These conducting bars, and loop circuits connected with them containing impedance coils and a source of electrical energy, such as a storage battery, constitute the equivalent of the cord circuits of manual exchanges and correspond identically with them in their functions. It will be seen that the number of subscribers' terminal carriages is equal to the number of subscribers' lines, but the number of cord circuits, or pairs of parallel bars necessary, needs not in practice be more than ten per cent of this number, this figure having been found safe in manual exchange practice. It is practically never found that all the subscribers wish to talk at the same time.

In the position of rest the carriages all occupy a position at one end of their respective sets of bars, one terminal of each being connected with a spring, termed the "ground-terminal spring," through which the line is placed in electrical connection with the commutator device described below, and through this at intervals with the ground. Movement is imparted to the carriage through a mechanical device consisting of a toothed sector engaging, by proper gearing, with a motor-driven shaft, as is more fully described below.

When a call is "set up" on the sending instrument at a subscriber's premises, a latch which holds this moving apparatus in position is dropped and engagement is made with the revolving pinion shaft so that the carriage is moved forward over the series of bars constituting the cord circuits.

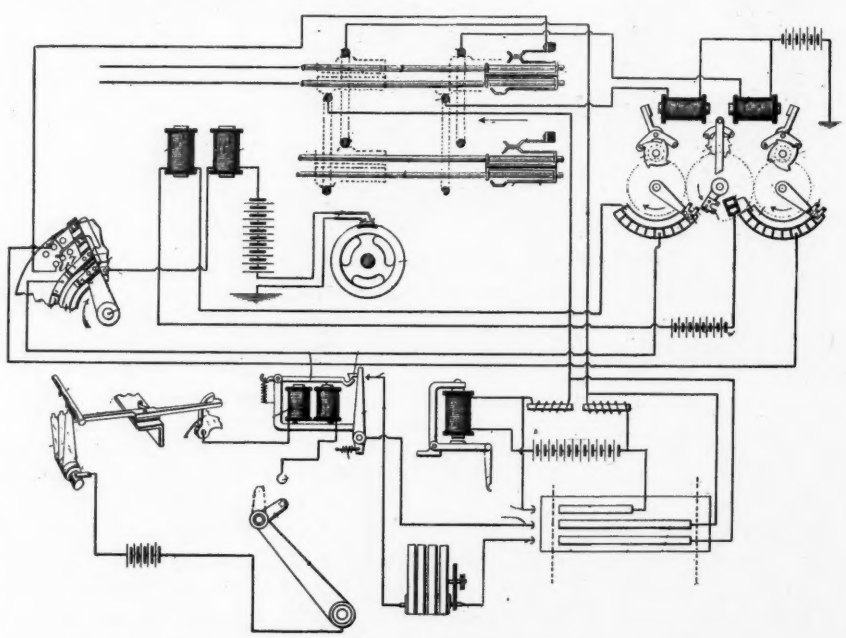


FIG. 2.—AUTOMATIC EXCHANGE APPARATUS—CENTRAL STATION CIRCUITS.

The latch holding this apparatus is partly operated by means of a device, designated the "busy-wheel," which consists of a number of thin radial steel

fingers set helically upon a shaft extending through the length of the apparatus, these fingers corresponding in number to the number of subscribers. This busy-wheel revolves constantly, except at the instant when a connection is being made, when it stops for an instant with one of its fingers in contact with the latch of the appropriate subscriber's terminal carriage. By mechanical means of great beauty, comprising movements springing these fingers in a direction parallel with the shaft of the busy-wheel, the unlocking of the latch retaining the carriage is effected. As, however, only one tooth at a time of the helically built busy-wheel can be thus sprung, it follows that only one carriage at a time can be moved.

The remainder of the apparatus comprises a power device, a selector, a ringer and a "busy test." The power device brings about all of the mechanical actions necessary to establish and disestablish a connection. It consists of a power-driven combination of parts, some of which are constantly moving while others move intermittently, the movements of the latter being controlled by magnets, which, in turn, are controlled directly from the subscriber's station through the selector. This power device is clearly shown in the accompanying photograph (at the near end of the apparatus).

The busy-wheel shaft is driven by friction gear and clutch from the power device and is arranged to be stopped by a pawl and ratchet operated by the starting magnet. This starting magnet initially controls the entire switch operation of the exchange. In addition to the starting magnet spoken of, a restarting magnet is used for the purpose of starting again this "master-shaft" for the purpose of starting into the gear the carriage-moving (or cord circuit-moving) apparatus of the called subscriber. The starting and restarting magnets operate in conjunction with the subscriber's sending apparatus through the medium of a controlling contact apparatus and selector. The rotating contact consists of two sets of circularly disposed contact points or pins, each set containing as many pins as there are subscribers, and two metal contact rings which are divided into a number of equal segments, generally ten. Sweeping over these contacts is a rotating trailer constantly driven by the power device (except when it is stopped, as is described below). This trailer is usually mounted upon the shaft of the busy-wheel. Each of the contact pins of one set is connected to a separate ground terminal spring, while one of the contact rings is connected in circuit with the starting magnet and a battery and the ground. One function of the contact device is to prevent the starting magnet from being operated by another subscriber while switching is going on, as its circuit is broken at all times except when the master-shaft is idle. As the rotation of the contact arm brings each subscriber's line momentarily, once in each revolution, in connection with the ground, a number of most important and valuable features are claimed as a consequence. One is the abolition of all individual magnets; another is that the subscribers are brought into fixed rotation in connection with the exchange, thus preventing any possibility of the double or mixed using of the power device, and this is regarded as a most important feature of the invention. Since

NEW TYPE FOUR-BLADED ALTERNATING-CURRENT CEILING FAN.

there are no cross or multiple connections whatever—even the ground connections being broken upon the carriage of a subscriber's circuit leaving the rest position—a perfect balance of circuits and a complete isolation of the pairs of subscribers conversing, one from another, may be obtained.

The selector magnets are controlled by the sending device at the subscriber's station and operated by it, when it is released, by means of a series of electrical impulses sent over the two sides of the line in parallel and the ground. The selector itself is power driven, the magnetic impulses received being used only to release various parts of the apparatus.

The space at disposal does not permit of going at great length into the numerous ingenious details of this system. Disconnection is accomplished by hanging up the telephones of the subscribers, permitting the mechanism to act in a reverse direction and the subscribers' carriages to come back to their normal rest positions. Some of the more interesting features of the operation of the system are its capacity for storing up calls, so to speak, at the subscribers' senders and disposing of them at the exchange, one at a time, as the apparatus for the purpose is released from other use. Another interesting feature is a continuous "trouble" test which goes on constantly, immediately connecting one of the lines (which may be that of the chief wire clerk) to the line in trouble, when trouble becomes evident.

As may be gathered from the above somewhat incomplete description, the operation of the Faller system closely follows that of the manual system, mechanical apparatus taking the place of the operator and performing almost exactly the same functions in connecting and disconnecting pairs of subscribers. The system is a "straight" central energy method, requiring no batteries at subscribers' stations. Ordinary station instruments can be used upon it without any change whatever.

Four-Blade Alternating-Current Ceiling Fans.

The accompanying illustration shows a new type of Tuerk four-bladed alternating-current ceiling fan recently brought out by the Hunter Fan and Motor Company, of Fulton, N. Y. The fan was designed to meet a demand for a ventilating apparatus of this type. Its special feature is its extraordinarily low consumption of current. With a sixty-inch spread of blades, the blades being eight inches wide, the fan operates at from 100 to 110 watts with an unusually high power-factor. The spiral groove oiling system that has always been used on the fans of this company's make is supplied with this special design, which also comprise a stopping and starting switch and a blade adjuster which can be used to change the angle on two of the blades while they are in motion. The fans are constructed to operate on commercial currents of from 50 to 230 volts at from 40 to 140 cycles per second. On the 40 and 50-cycle fans a specially constructed motor is used, giving a revolution speed of 180 turns per minute with a five-foot spread of blades, eight inches wide, and a consumption of only ninety watts of current at full speed.

The two-bladed ceiling fans for alternating current made by the same company also exhibit the remarkable economy of 100 watts at full speed of operation and, on this account, little change has been made this year in the design of these appliances.

New Fan Motors.

A new line of fan motors is being offered this year by the Fort Wayne Electric Works, Fort Wayne, Ind. The most unique of the several types of motors presented is the one known as the "Wood" revolving fan motor (Fig. 1), which is of

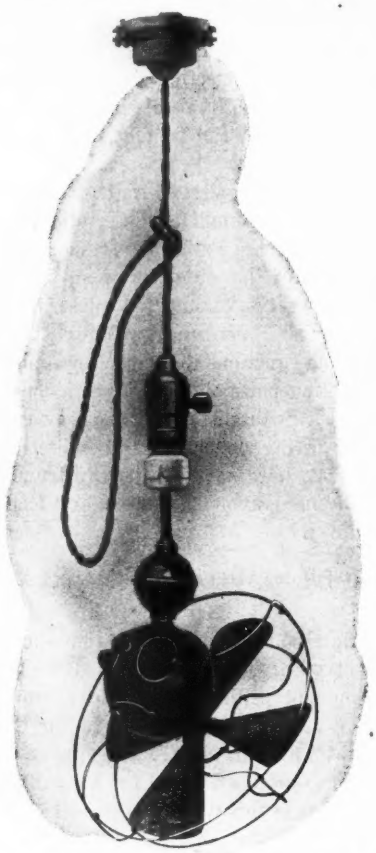


FIG. 1.—REVOLVING FAN MOTOR WITH CORD SUSPENSION.

the ordinary high-speed type. It consists of a spherically incased motor suspended from a ball-bearing so as to revolve around a vertical axis. The case of the motor is small and of light weight, being three and five-eighths inches in

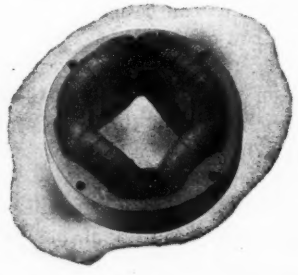


FIG. 2.—FIELD MAGNET, ALTERNATING-CURRENT FAN MOTOR.

diameter and cast of aluminum. The shaft of the motor upon which the fan is mounted is placed at an angle of forty-five degrees to the vertical axis of the complete structure. The result is that since the top fan blades are farther from the centre of rotation than the lower blades an unbalanced condition is produced,

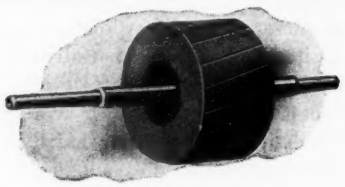


FIG. 3.—ARMATURE, ALTERNATING-CURRENT FAN MOTOR.

which causes the motor to revolve in a horizontal plane, distributing at in-

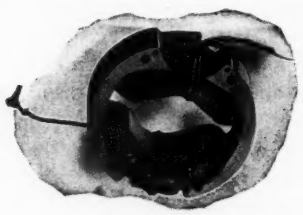


FIG. 4.—FIELD MAGNET, DIRECT-CURRENT FAN MOTOR.

tervals the air to all parts of the room. The motors are made for both alternating

FIG. 5.—ARMATURE, DIRECT-CURRENT FAN MOTOR.

and direct current. The alternating-current motor is of the induction type, provided with a four-pole field magnet (Fig. 2) and a squirrel-cage armature (Fig. 3). It will be noticed that the slots in the core of the armature are slanted, the object of this being to prevent humming. The direct-current motor is provided with a two-pole field magnet (Fig. 4) and a squirrel-cage armature of the drum-wound type (Fig. 5). The slots in this armature are diagonal to the face of the core, the construction being similar to that of the alternating-current armature above described. Carbon brushes of rectangular cross-section are used and are mounted in brass tubes into which they fit closely. The brushes are pressed against the commutator by springs that are contained in the tubes immediately back of the brushes, the spring tension being adjusted by means of screws in the back ends of the brush-holders. The bearings are of the self-oiling type.

The line of desk-type motors (Fig. 6) is similar to the revolving type, with the exception that the motors are mounted on a solid base, the ball-bearing suspension being omitted. They are built for both alternating and direct current, and the construction is similar to the revolving type, with the exception above mentioned.

These machines are all provided with eight-inch fans and run at a maximum speed of 2,200 revolutions per minute.

The power consumption is as follows: 50-volt motor, 17 watts at 60 cycles, 36 watts at 140 cycles; 104-volt motor, 17 watts at 60 cycles, 36 watts at 140 cycles; 115-volt direct-current motor, 17 watts.

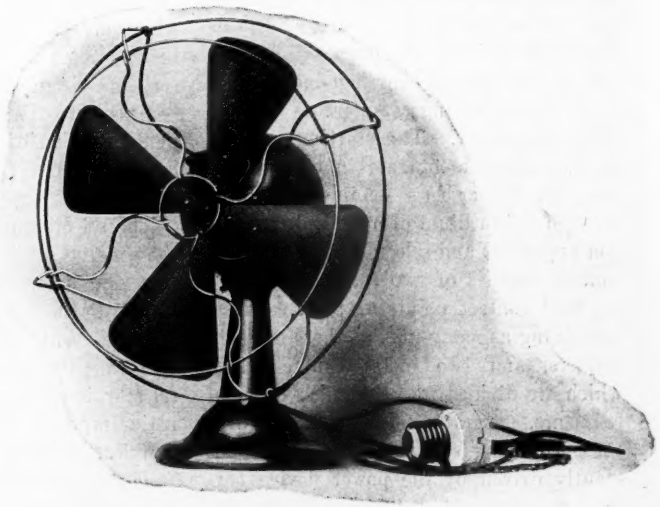


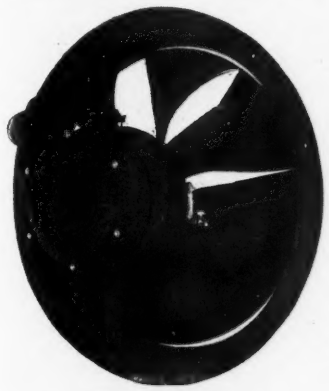
FIG. 6.—DIRECT-CURRENT DESK FAN-MOTOR.

Electrical Smoke Detector.

An electrical smoke-detector alarm, which depends for its principle upon the peculiar action of smoke on a fibre which has been subjected to a certain treatment, has been patented recently. The fibre, which may be of silk or a horse-hair, is boiled in a closed vessel for about twenty minutes in a six to ten-per-cent solution of commercial soda, then dried while very moderately stretched in a tube from which the air is exhausted. The inventors state that they are unable to precisely explain what transformation is produced in the fibre by treating it as above described, but it is found that when smoke comes in contact with fibre so treated an elongation invariably results. This elongation is made to close an electrical alarm circuit.

Sturtevant Propeller Fans.

The electric propeller fan manufactured by the B. F. Sturtevant Company, Boston, Mass., is excellently illustrated in the ac-



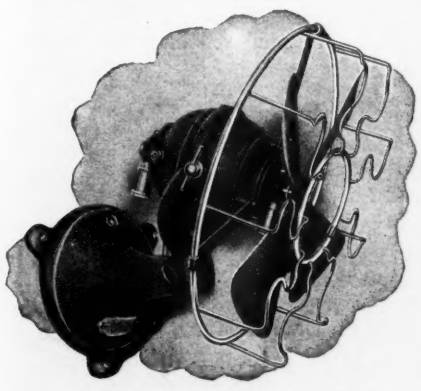
PROPELLER FAN.

companying engraving. This fan is self-contained and can be placed in any location that may be desirable. The fan is constructed of careful mechanical balance, the curvature of the blades being made such as to give high efficiency. The motors are manufactured by the Sturtevant company and are of a two-pole dustproof and water-proof type, very carefully designed to fulfill the difficult requirements of their service without overheating. It is claimed that they will carry their full-rated load for ten hours without sparking and without rise in temperature of more than fifty degrees centigrade above the surrounding atmosphere.

New Types of Electric Fans.

The Lundell fan was among the pioneers in fan construction and rapidly won a high place in popular favor by reason of its mechanical and electrical excellence.

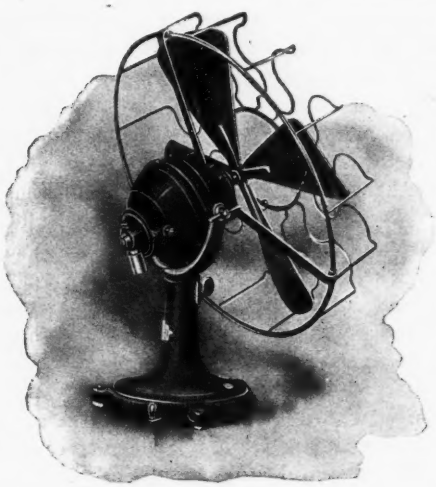
The manufacturers are constantly on the



SWIVEL AND TRUNNION BRACKET FAN.

watch for possible improvements, and it is because of the advantages of design and the thoroughness of construction that the Lundell fan is still greatly in demand.

To meet the increasing demand this season new types have been introduced, namely, the twelve and sixteen-inch swivel and trunnion desk and bracket patterns. They are made with the same degree of careful workmanship as the other types, are finished in an attractive style, have self-aligning and self-oiling ring bearings, and a starting and regulating switch giving variations of speed. They are listed



SWIVEL AND TRUNNION DESK FAN.

in Catalogue No. 3,046, which may be obtained by addressing the Sprague Electric Company, 527 West Thirty-fourth street, New York city.

A Large Order for Fans.

Word has come from the South that a boom in business is being enjoyed, the Newman-Spranley Company, Limited, of New Orleans, La., reporting that such a condition prevails in all its departments, particularly in electrical apparatus.

This company has taken the agency for the full line of goods manufactured by the Diehl Manufacturing Company, Elizabethport, N. J. Over thirty Diehl motors and fans were sold during the past month. It is a peculiar fact that while the cities in the North were snowbound, this company was enjoying fine weather and sold a good many fans.

It is a just tribute to the business ability of the Newman-Spranley Company to state that it anticipated an increasing demand for fans and made preparations to meet it. A shipment of its stock order has been received, consisting of six carloads, and includes an assortment of both types of ceiling, two and four-blade, electrolier column in ten designs and all finishes; also desk, bracket, trunnion and universal joint desk, in three sizes. This makes a very large order and a great assortment to select from.

The American Street Railway Association.

TO THE EDITOR OF THE ELECTRICAL REVIEW:

The twenty-first annual meeting of the American Street Railway Association will be held in the Light Guard Armory, Detroit, Mich., Wednesday, Thursday and Friday, October 8, 9 and 10, 1902.

Papers will be presented on the following subjects: "The Registration of Transfers," "Benefit Associations," "Discipline of Employés by the Merit System," "The Transportation of Light Express and Parcel Delivery," "Steam Turbine Engines," "Signals for Urban and Interurban Railways," "The Adjustment of Damage Claims."

We expect to have a fine exhibition of street railway supplies.

Thursday, October 9, has been set apart as a day for the examination of the exhibits. No session of the association will be held, so that all may have ample time to view the exhibits.

The annual banquet will be held on Friday evening, October 10, when the officers-elect will be installed.

The headquarters of the association will be at the Cadillac Hotel. No rooms will be assigned prior to April 15, the assignment to be made under the supervision of the local committee. Members intending to be present are requested to apply for rooms at once, so there may be no disappointment in this regard. Preference will be given to representatives of members of the association if application is filed in time.

Other first-class hotels are Russell, Wayne, St. Clair, Normandie, Griswold and Metropole.

Railroad rates will probably be as in former years.

The following resolution was unanimously adopted by the committee.

"The secretary is directed to request the chief executive officer of the different companies to notify all delegates and heads of departments attending the convention that they are expected to be present at all sessions of the meeting and take part in the discussions."

Another circular will be issued later, giving particulars regarding the meeting.

T. C. PENINGTON, Secretary.

Chicago, March 1.

Wireless Telegraph Instruments Wanted.

TO THE EDITOR OF THE ELECTRICAL REVIEW:

Can you inform me where I can obtain two wireless telegraph instruments?

I have a telephone system on this island (San Juan, Wash.) and wish to establish communication with Whatcom, a distance of twenty miles.

V. J. CAPRON, M. D.

Roche Harbor, Wash., March 11.

Some of the Exhibitors at the Chicago Automobile Show.

The National Vehicle Company, of Indianapolis, occupied a space in the central portion of the building and arranged an attractive exhibit of its vehicles. There were its "Electrobile," models 50 and 55; its road wagon, models 60 and 65; its runabouts, in two designs, and a stanhope and park trap. The National vehicles are equipped with batteries made by the Western Storage Battery Company. The company has great hopes for the future of the electric carriage, and believes it will grow more popular the more the public knows of it. It is making a beautiful line of vehicles and is pleased with its share of the trade.

The Fanning Manufacturing Company, of Chicago, had on exhibition a very handsome electric runabout of graceful lines and elegant finish. This is a young company, and at the next show will no doubt have a number of new designs on exhibition.

The Joseph Dixon Crucible Company, of Jersey City, so well known to the electrical trade, also makes its influence felt in automobile circles. Its exhibit at this show was a very handsome one, making most prominent, of course, the famous Dixon's pure flake lubricating graphite.

The Hydra Double Battery Company, of New York, made an exhibit of its cells. The company says that the popularity of this "sealed-up semi-dry battery" in Europe, where it was introduced four years ago, promises to be more than equaled in America.

The D. M. Steward Manufacturing Company, of Chattanooga, Tenn., manufacturer of a number of electrical devices, introduced an article for removing grease, ink or stains from the hands. It is called "stain off," and is said to be of great convenience to all who have to do with machinery.

The Dayton Electrical Manufacturing Company was represented at the show by Messrs. A. A. Allen and V. G. Apple, showing the Apple igniting apparatus as applied to the Elmore, Stearns, Remington and Winton automobiles. One of the special features of its exhibit was the Apple indicating automatic switch, which automatically cuts out the battery when not in use and switches to and from the dynamo.

Forty thousand visitors entered the Coliseum during the eight days of the show. General Manager Miles said that every expectation of the Automobile Club and the Manufacturers' Association, under the combined auspices of which the show was given, had been more than realized. The manufacturers who placed exhibits expressed themselves as being well pleased with the results. Exact figures could not be secured, but it was said that orders for $750,000 worth of machines were taken by the exhibitors during the show. Some of the firms have been obliged to stop taking orders while the week was yet young, saying that they had booked all they could look after for some time to come. Chicago was the Mecca of automobile dealers during show week, and it is said that no less than 1,200 were present. This accounts for the large number of orders taken by the exhibitors. In all there were 120 machines on exhibition.

It is believed that the Chicago Automobile Show of 1902 has been the best yet held in any city. It has shown what great interest is taken in the horseless carriage throughout the West. It has shown most remarkable improvements in every style of vehicle. It gives promise of continued approach to perfection.

The automobile has been truly called the great road reformer. It has a great work to do throughout the West, where millions upon millions of dollars are annually spent and lost in poor highways; but that it will accomplish this work no one can doubt who has witnessed the enthusiasm of the manufacturers, dealers, automobilists and the general public in the horseless carriage and its development.

Following is a list of leading exhibitors:

Apperson Brothers Automobile Co., Kokomo, Ind.
American Darracq Automobile Co., New York.
Automobile Equipment Co., 21 Quincy street, Chicago.
Beardsley & Hubbs Manufacturing Co., Shelby, Ohio.
Badger Brass Manufacturing Co., Kenosha, Wis.
Brown-Line Gear Co., Syracuse, N. Y.
Baldwin Chain Co., Worcester, Mass.
Buffalo Gasoline Motor Co., Buffalo, N. Y.
Buffalo Electric Vehicle Co., Buffalo, N. Y.
Buffalo Automobile and Auto-Bi Co., Buffalo, N. Y.
Baker Motor Vehicle Co., Cleveland, Ohio.
Chicago Motor Cycle Co., 107 Madison street, Chicago.
Chicago Motor Vehicle Co., 341 Wabash avenue, Chicago.
Crest Manufacturing Co., Cambridgeport, Mass.
Dixon, Joseph, Crucible Co., Jersey City, N. J.
Dayton Electrical Manufacturing Co., Dayton, Ohio.
Dow Portable Electric Assistant Co., Boston, Mass.
Dayton Motor Vehicle Co., Dayton, Ohio.
Dietz, R. E., & Co., New York.
Electric Vehicle Co., Hartford, Ct.
Elmore Manufacturing Co., Clyde, Ohio.
Eastman Metallic Body Co., Cleveland, Ohio.
Fanning Manufacturing Co., Chicago.
Fournier-Searchmont Co., Philadelphia, Pa.
Foster Automobile Co., Rochester, N. Y.
Friedman Automobile Co., Chicago.
Franz Body Co., Akron, Ohio.
Hill Engine Co., Kenosha, Wis.
Haynes-Apperson Automobile Co., Kokomo, Ind.
International Motor Car Co., Toledo, Ohio.
International Automobile and Vehicle Tire Co., New York.
Locomobile Company of America, New York.
Mobile Company of America, Tarrytown-on-Hudson, N. Y.
Merkel Manufacturing Co., Milwaukee, Wis.
Merriam-Abbot Co., Cleveland, Ohio.
Midgley Manufacturing Co., Columbus, Ohio.
Milwaukee Automobile Co., Milwaukee, Wis.
Motsinger Device Manufacturing Co., Pendleton, Ind.
Motor Cycle Manufacturing Co., Brockton, Mass.
National Vehicle Co., Indianapolis, Ind.
New York Belting and Packing Co., New York.
National Carbon Co., Cleveland, Ohio.
Overman Automobile Co., New York city.
Olds Motor Works, Detroit, Mich.
Ohio Automobile Co., Warren, Ohio.
Peerless Manufacturing Co., Cleveland, Ohio.
Porter Battery Co., Waukegan, Ill.
Rochester Machine Tool Co., Rochester, N. Y.
Spaulding Automobile Co., Buffalo, N. Y.
Stewart Manufacturing Co., Chattanooga, Tenn.
Twentieth Century Manufacturing Co., 17 Warren street, New York.
Twyford Vehicle Co., Pittsburgh, Pa.
Veeder Manufacturing Co., Hartford, Ct.
Whitney Manufacturing Co., Hartford, Ct.
Winton Motor Carriage Co., Cleveland, Ohio.

OPINIONS OF SUBSCRIBERS.

"One of the Best."

To the Editor of the Electrical Review:

We regard the Electrical Review as one of the best papers published.

Electric Machinery Co.,
C. H. Chalmers.

Minneapolis, March 7.

"Prize Most Highly."

To the Editor of the Electrical Review:

Enclosed please find my check with request for continuation of subscription of your valued journal, which I prize most highly. G. Wilbur Hubley.

Louisville, March 3.

"Shall Continue."

To the Editor of the Electrical Review:

I have received the Electrical Review for several years and have noted its growth and have come to appreciate its importance. I shall continue to be a subscriber. J. H. Bickford.

Salem, Mass., March 4.

"With Pleasure."

To the Editor of the Electrical Review:

We have been the recipient of your paper for a number of years. It is with pleasure that we enclose you our check.

American Watch Tool Co.,
S. A. Barton, Manager.

Waltham, Mass., February 28.

From Atlanta to the Metropolis.

To the Editor of the Electrical Review:

I beg to hand you herewith post-office order in payment for the Electrical Review for one year.

Wm. W. Kingston,
Southern Agent, Lorain Steel Co.

Atlanta, March 3.

"Cheerfully."

To the Editor of the Electrical Review:

I most cheerfully enclose my check for so good a paper. Patrick B. Delaney.

South Orange, March 4.

Appreciated.

To the Editor of the Electrical Review:

We shall send you our check in a few days for the Electrical Review. We would not drop it under any consideration.

Natick Gas and Electric Co.,
Fred J. Lucey, Manager.

Natick, Mass., March 1.

General Eckert Retires from the Western Union Presidency.

COLONEL ROBERT C. CLOWRY IS PROMOTED TO THE PRESIDENCY.

On March 12 General Thomas T. Eckert, for several years president of the Western Union Telegraph Company, retired from the presidency of that corporation to become chairman of the board of directors, which office carries with it the chairmanship of the executive committee. Colonel Robert C. Clowry was elected president and general manager to succeed General Eckert. Colonel Clowry has been for some time vice-president of the company and general superintendent of the western division. He becomes, through the new arrangement, the operating head of the great telegraph system, while General Eckert retains general supervision of the company's affairs. The change was made through the feeling of the directors that, at his great age, General Eckert should be relieved of some of the more arduous duties of his important position.

Thomas Thompson Eckert was born in St. Clairsville, Ohio, April 23, 1825. In 1849 he was appointed postmaster at Wooster, Ohio, he being at that time a telegraph operator. In 1852 he constructed the telegraph line from Pittsburgh to Chicago over the Fort Wayne route. He became the superintendent of the line and received a more responsible place after that line became a part of the Western Union system. In 1859 he resigned from the telegraph service to take the superintendency of some gold mines in Montgomery County, N. C., and was located there when the Civil War began. Upon its outbreak he was placed in charge of the Military Telegraph Department of the Potomac, with the rank of captain, and served in the militia with General McClellan. In September, 1862, he was called to Washington, where he was thrown into very confidential relations with President Lincoln and other leaders. There he was put in charge of the Military Telegraph headquarters in the War Department Building, and in 1864 was brevetted lieutenant-colonel and made Assistant Secretary of War under Secretary Stanton. In 1865 he was brevetted again brigadier-general for distinguished services and shortly afterward resigned, assuming the important position of general superintendent of the eastern division of the Western Union Telegraph Company's lines.

He assisted in the reorganizing of the cable business and in 1875 was appointed president of the then reorganized Atlantic & Pacific Telegraph Company. Upon the consolidation of the present Western Union company, General Eckert was made vice-president, and shortly afterward became the president of the company. He has been always its virtual head and director.

Colonel Clowry, the incoming president, started at the lowest step of the telegraph business as a messenger boy and

GENERAL T. T. ECKERT.

graduated to the key by the display of handy and alert qualities. During the Civil War he was superintendent of a military telegraph division in the southwestern states. In the West he has made much the same record in the management of the telegraph system that General Eckert made in the East. Situated at Chicago for many years past, Colonel Clowry has risen by successive steps to

COLONEL R. C. CLOWRY.

occupy the position of vice-president of the Western Union company, from which he has just been elevated to the presidency.

The record of the two men is of the kind that reflects credit upon American industrial undertakings. Both starting with small beginnings have won their way to positions of high eminence and importance in industrial life by force of sheer ability and hard work.

American Electrochemical Society.

The initial meeting of the American Electrochemical Society will be held in Philadelphia on April 3, 4 and 5. The meeting has been called by a number of gentlemen interested in electrochemical subjects, and a programme of unusual interest has been prepared. Those desiring to enrol themselves as members are requested to communicate with Mr. C. J. Reed, No. 3313 North Sixteenth street, Philadelphia.

The afternoon of Thursday, April 3, will be given over to visits to places of interest, among them the chemical works of Harrison Brothers & Company, and Thursday evening, at eight o'clock, the inaugural meeting will be held at the Manufacturers' Club, 1409 Walnut street. This will be devoted to the organization of the society, the adoption of a constitution and by-laws, the election of officers, the determination of times and places for future meetings, and other questions of similar interest. Friday two sessions will be held, at nine o'clock and two o'clock, in the John Harrison Laboratory of Chemistry of the University of Pennsylvania. In the evening an informal reception will be held at the Manufacturers' Club.

Saturday morning another session for the reading of papers will be held at the University, and in the afternoon visits will be made to the Bethlehem Steel Company's works, the Lehigh Zinc Works and the Lehigh University, at Bethlehem, Pa., the train leaving the Reading terminal in Philadelphia at 12.30.

Among those who will read papers at the meetings are the following: Professor Jos. W. Richards, Professor Wilder D. Bancroft, Dr. Pedro Salom, Dr. C. W. Volney, Professor Louis Kahlenberg, Dr. N. S. Keith, Professor C. F. Burgess, Mr. Chas. E. Acker, Mr. Woolsey McA. Johnson, Mr. Clarence L. Collins, Mr. C. J. Reed, Mr. Carl Hering, Professo. Chas. A. Doremus, Mr. Herbert H. Dow, Mr. Samuel S. Sadtler, Dr. Herman Schlundt, Dr. Konrad Norden, Dr. E. F. Roeber, Mr. Arvid Reuterdahl.

National Electric Light Association Convention.

The twenty-fifth convention of the National Electric Light Association will be held at Cincinnati, Ohio, on May 20, 21 and 22. Association headquarters will be at the Grand Hotel, where special rates will be arranged. It is expected that some innovations in the programme will make the occasion one of the most interesting in the association's history.

CURRENT ELECTRICAL NEWS

COMMERCIAL NEWS

DOMESTIC AND EXPORT

ELECTRIC TRACTION IN SOUTH AFRICA—The reorganization of the Johannesburg, South Africa, electric traction, light and general power system has been sanctioned. The combined projects will result in an estimated expenditure of between $1,500,000 and $2,000,000. The electrical expert to be specially engaged for the purpose of acting as consulting engineer in the matter has, however, according to last advices, not yet been named.

CLEVELAND, OHIO—It is announced that the terms for the consolidation of the Cleveland Electric Railway Company and the Cleveland Street Railway Company have been agreed upon. The Consolidated company will include every street car line in the city and will be operated under the presidency of Senator M. A. Hanna. Large improvements are contemplated, the details of which have not yet been arranged. Stock to the value of $21,600,000 is involved.

STORAGE BATTERY CONSOLIDATION—It has been announced that a combination of large storage battery interests has been effected. It is understood that the United States Battery Company and the International Storage Battery Company have been consolidated under the title of the Consolidated Storage Battery Company. The capital stock is stated at $10,000,000. The company has been incorporated at Trenton, N. J., and purposes to open branch offices in the principal cities of the country.

LARGE POWER PLANT IN MASSACHUSETTS—The Boston & Northern Street Railway Company has purchased a piece of land in Danversport which is to be used to establish a large power plant. It is stated that the cost will be $1,000,000. It is proposed to locate there a plant to take the place of those at Essex Falls, Lawrence, Wakefield and other places; and manufacture all the power at this point. The location is such that coal and other material can be landed from vessels right beside the station, and besides, there is a spur track from the Boston & Maine running close to this land.

STREET CAR CONSTRUCTION COMBINE—Contracts merging the Steel City Railway Company and Warrior River Power Company into the Birmingham & Steel City Railway and Power Company, and providing for the financing of this organization, have been signed at Birmingham, Ala. The parties to the deal whose names are made public are: J. W. Adams and R. R. Zell, representing the companies, and J. P. Hornady, of the Maltby-Hornady Company, of Cincinnati. The object of the new company is to build a street car system for which a franchise was recently granted. The company is organized with a capital stock of $2,000,000.

TELEPHONE AND TRAIN SERVICE—In connection with the "overland limited" trains the managements of the Northwestern, Union Pacific and Southern Pacific roads have decided to provide a quick service telephone system for the use of patrons while the trains are standing at the depots at Chicago, Omaha and San Francisco. This novel innovation will be started about April 1, when the new equipment, which is to cost nearly $2,000,000, will be ready to put into service. A large proportion of the patrons of the "overland limited" are business men and men of wealth, whose time is valuable and to whom telephone service at the moment of leaving the cities named frequently will prove valuable. General Passenger Agent W. B. Kniskern, of the Northwestern, stated recently that arrangements had been completed here with the telephone company for the installation of the service at the Wells street depot, as soon as the new trains are ready.

SAN FRANCISCO STREET CAR DEAL—The details of the San Francisco traction combination has been announced recently. The plan that the syndicate headed by Brown Brothers & Company is underwriting contemplates the purchase of the Market Street Railway and other lines in San Francisco. A corporation called the United Railways Investment Company, of San Francisco, will issue $15,000,000 five per cent cumulative preferred and $5,000,000 common stock. It will own the bonds, preferred and common stocks of the United Railroads of San Francisco, the stock and bonds of which will be $20,000,000. The latter company will furnish $1,600,000 cash for betterments and improvements and will reserve stock to take up minority stock of lines, the control of which has been already acquired. The combined system has a mileage of 229. It earned last year $5,125,282 gross and $2,083,155 net.

GEORGIA POWER COMPANY TO BE INCORPORATED—Application has been made for a charter for the Atlanta Water and Electric Power Company. This company is to establish a big electric light and water plant on the banks of the Chattahoochee River. The company is to be capitalized at half a million dollars, all of which amount is to be paid in. The incorporators desire authority from the court to increase the capital stock to $2,500,000, should a majority of the stockholders so vote. The incorporators are: S. Morgan Smith and S. Fahs Smith, of York, Pa.; John C. Temple, of Philadelphia; Forrest Adair, George Adair, George W. Adair and Jack J. Spaulding, of Fulton County. It is understood that the purpose of the company is to furnish electric power at such cost that manufacturers in Atlanta and in the county will find it cheaper to operate their plants by electricity instead of steam, as many are doing at present. It is expected that the company will have an electric railway line running from its plant to the city. It will also be the purpose of the company to furnish electricity for lighting purposes, and it is said that work on the plant will begin immediately after the charter has been granted by the Superior Court. It is understood that all the necessary preparations have been made, and that those interested are only waiting for a charter.

ELECTRIC RAILWAYS

MIDDLETOWN, IND.—The general council of Middletown has granted a fifty-year franchise to the Merchants' Traction Company, of Anderson. The terminal will be on High street, at the corner of High and Fifth.

CLEVELAND, OHIO—It is expected that within the next six months the systems of the Pomeroy-Mandelbaum Syndicate, operating 130 miles of suburban railway property, will be radiating from this city. The first regular car over the Cleveland & Southern to Medina will probably be run within the next two weeks.

BOSTON, MASS.—The new Suburban Electric Street Railway Company has recently purchased the Parmenter Crayon Works in Waltham, for the purpose of erecting on the site thereof a large power plant in connection with the Waltham Gas Light and Electric plant which adjoins it, and which is now owned by the Suburban company. The Suburban company has also in contemplation the extension of its line to Weston, provided it shall succeed in securing a franchise for the whole town, as now seems probable.

STATEN ISLAND, N. Y.—The Staten Island Electric Railroad Company, the New York & Staten Island Electric Company and the New Jersey & Staten Island Ferry Company have been placed in the hands of John Greenough, as receiver, by the Supreme Court. The obligations of these companies represent several millions of dollars, and are held chiefly by some of the largest financial institutions and capitalists in the city. It is understood that the application for a receiver was friendly, and was taken as a preliminary step toward a reorganization and consolidation of the various interests. Mr. Greenough, when seen recently, said that he had been appointed receiver merely as a preliminary step toward reorganization, and that he himself was one of a committee of bondholders who had instigated the move.

AUTOMOBILE NOTE

THE AUTOMOBILE CLUB OF AMERICA, through the runs and tours committee, announces the following runs to be held this spring and summer: March 29—Ardsley; leaving at 10 A. M., *via* Mamaroneck and White Plains to Ardsley, where lunch will be served. April 12—Staten Island; leaving at 9 A. M., *via* Jersey City, returning *via* St. George; lunch at Tottenville. April 26—Long Island Automobile Club Endurance Test. May 10—Nyack; leaving at 9 A. M., *via* Tarrytown, returning *via* New Jersey side; lunch at St. George, Nyack. May 24—Run on Long Island; details later. June 6—Spring tour to Philadelphia—Atlantic City, three days' run; leaving at 9 A. M. June 14—Morris Park; run to races. June 21—Lake Hopatcong, New Jersey; two days.

ELECTRICAL SECURITIES

This week in the market has shown a decided improvement in general, with a decidedly bullish condition of affairs toward the close. This will undoubtedly be reflected in better prices during the coming week.

This confidence was inspired by the improvement in the monetary outlook and the belief that there will not be the threatened advance in rates. This change in opinion is based on the comparatively favorable bank statement last week and the expectation that another and even better showing will be made next Saturday. The fact that the small surplus reserves of the banks were saved from extinction by the decreases in loans and deposits also had a stimulating effect upon sentiment. This is regarded as significant, as this reduction was made by the action of the larger banking and financial interests—as shown by the fact that there was no liquidation the past week of this volume—and is accepted as plainly indicating the fact that the powerful interests named are prepared to protect the money as well as the stock market.

The papers that have been filed in the Federal suit against the Northern Securities Company in the United States Circuit Court at St. Paul, Minn., disclosed little that was new. There has been apparently nothing done in regard to the reported movement to secure a quick legal decision on this important and far-reaching legal question from the United States Supreme Court. As we have stated before, it will probably be some time before a final decision will be reached.

ELECTRICAL SECURITIES FOR WEEK ENDING MARCH 15.

New York:	Closing.
Brooklyn R. T.	65
Con. Gas	223½
Gen. Elec	307
Man. El	134¼
Met. St. Ry	167½
Kings Co. Elec	190
N. Y. & N. J. Tel Co	168
Telep., Tel. & Cbl. Co	5
Westing. Mfg. pf	198

A feature of the market this week was a rise at one time of about 15 points in Westinghouse Electric (with a close showing a net gain of 8⅞ on dealings in 6,000 shares).

The General Electric keeps up its stride, rising to 307 this week. It is stated that the earnings of the past year aggregated $12,000,000, or about 40 per cent upon the present capitalization.

Boston:	Closing.
Am. Telep. & Tel	167½
Edison Elec	265
New England Tel	142½
Mass. Elec. pf	97
Western Telephone & Telegraph	93

Philadelphia:	Closing.
Elec. Co. of America	7⅝
Philadelphia Elec	5¼
Union Traction	39¼
United G. I. Co	118½
Elec. Stor. Bat. c	63
Elec. Stor. Bat. pf	65

There was a revival in strength in Electric Company of America, stock that has been in seclusion for some time. Union Traction, Philadelphia Company, and Philadelphia Electric made slight gains.

United Gas Improvement Company directors have declared the regular quarterly dividend of 2 per cent, payable April 15 to stock of record March 31.

Chicago:	Closing.
Central Union Tel	40
Chicago Edison Light	175
Chicago Telep	185
Metropolitan El. pf	90½
National Carbon	20
National Carbon pf	84½
Union Traction	15¾
Union Traction pf	50½

ELECTRIC LIGHTING

SALEM, MASS.—The Salem Electric Lighting Company has begun work in remodeling its plant on Peabody street, and will replace the present machinery with new and later machinery, at a cost of $500,000.

SEATTLE, WASH.—The Chamber of Commerce has passed a resolution endorsing the proposed municipal light plant at Cedar Falls. There was but little discussion of the resolution and it met with but little opposition.

RED BLUFF, CAL.—A surveying party is now laying out the line for the Northern California Electric Power Company's pole line from Palacedo to this place, and already a force of men is at work digging holes and putting up the poles. The company was fortunate in securing several carloads of poles which were intended for shipment elsewhere, and these will be set up at once.

CARBONDALE, PA.—The Lackawanna Valley Electric Light and Power Supply Company of this city has been branching out and has absorbed the Crescent Electric Light Company, of Archbald, and the Jermyn Electric Light Company. It has controlled the Forest City Electric Light Company for some months. This practically gives the local company control of everything in the electric lighting line between Archbald and Forest City.

MOBILE, ALA.—It is probable that all wires in the business district will be put underground before the asphalt pavement is laid. The Electric Light and Railway Company will make application to the council for permission to put its commercial light circuit underground, and the Mobile Electric Lighting Company will, it is said, do the same. The Bell Telephone Company is already laying its service tubes, and the Home Telephone Company is seriously considering the same action.

SEATTLE, WASH.—The official contract between the city and the Seattle Electric Company for furnishing street lights during the year 1902 has been filed in the office of the City Controller. By the contract the company agrees to furnish all arc lights at $6 per month or $75 a year. Thirty-candlepower incandescent lights will be charged for at the rate of $1.25 a month, or $15 a year each. It is estimated that the cost of lighting the city this year will be $35,000.

TELEPHONE AND TELEGRAPH

DAYTON, OHIO—The unfinished Home Telephone Company in this city has been purchased from the Everett-Moore Syndicate by Dayton and Columbus business men for $89,000.

EAST MAUCH CHUNK, PA.—At the regular monthly meeting of the town council it was voted to extend the time limit of the ordinance granted to the Consolidated Telephone Company until May 15.

GREENVILLE, TEX.—The new telephone system of this city has been completed and an application has been made for a charter. The new company will do business under the name of the Greenville Telephone Exchange.

JOPLIN, MO.—It is announced that enough stock of the Joplin Telephone Company has been secured by the new company to give the new stockholders control of the plant, and that at the next meeting arrangements will be made whereby the plant will be turned over to the new company.

WAUSAU, WIS.—The Wausau Telephone Company expects to spend a great deal of money this spring putting in metallic circuits and making other improvements. The toll line will be extended eastward to Hogarty to meet another line from Birnamwood, which connects Antigo and other points.

GLOVERSVILLE, N. Y.—The Glen Telephone Company is arranging to put its telephone system underground. The cable material has arrived and work will be commenced at once to lay the conduits. It will be necessary to increase the present capacity of the switchboard and numerous other extensions are anticipated.

ANDERSON, IND.—A large number of farmers living within a radius of five miles south of here have organized a telephone company, which will connect its lines with those of the Central Union or Anderson Telephone Company. With these new lines nearly 1,000 farmers in Madison County will have telephones in their homes.

EAU CLAIRE, WIS.—A new telephone corporation has taken the franchise in this city of the Oszo Telephone Company, which, however, continues to operate over a large territory. The new company is the Wisconsin & Minnesota Telephone and Telegraph Company, with headquarters in Eau Claire. A. S. Munzell is the general manager.

LEGAL NOTE

NEGLIGENCE IN CONTRIBUTING TO INJURY—The question whether or not a boy ten years old is guilty of negligence contributing to his injury is held, in Roberts *vs.* Spokane R. Co. (Wash.) 54 L. R. A. 184, to be for the jury, where at a street crossing he attempts to ride a bicycle across street railway tracks, and in so doing passes behind one car and comes immediately in front of another approaching from the opposite direction which, because of its defective condition, can not be stopped in time to avoid collision with him.

INDUSTRIAL ITEMS

THE FORT WAYNE ELECTRIC WORKS, Fort Wayne, Ind., has a bas-relief illustrating its March calendar. Part of the formation of the panel is taken up with three designs of its type-K induction wattmeters.

THE BULLOCK ELECTRIC MANUFACTURING COMPANY, Cincinnati, Ohio, has added another to its historic series. A portrait in colors of Sir Charles Wheatstone together with a short biography is treated in its March calendar card.

THE JENNEY ELECTRIC MANUFACTURING COMPANY, Indianapolis, Ind., describes and illustrates in Bulletin No. 160 the Jenney multipolar dynamos. Sectional and part drawings of the engines in different states of assembling give a very good idea of the construction of this apparatus.

STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., has opened an office in the Douglass Building, Third and Spring streets, Los Angeles, Cal. The company is represented in this office by Messrs. John Martin & Company, who already have offices established at San Francisco, Cal., and Seattle, Wash.

THE TIRRILL REGULATOR COMPANY, Concord, N. H., announces that the General Electric Company, of Schenectady, N. Y., has acquired all rights and interests and that all communications relative to engineering advice, orders for repair parts for regulators, etc., should hereafter be addressed to the General Electric Company.

THE PATTESON PRESS, New York city, is favoring its patrons with a handsome and very useful calendar. A large pad, 6 by 8¼, is mounted upon a durable and handsomely printed background; each leaf of the pad contains a single figure in bold lettering five inches high, which is visible within the limits of the largest office room.

THE VOUGHT-BERGER COMPANY, La Crosse, Wis., manufactures intercommunicating telephone sets, bridging telephones, and other telephone devices. This company also manufactures a lamp-adjusting apparatus for drop lamps, consisting of two balls, within each of which is concealed a vulcanized hard-fibre flanged pulley, over which the cord passes.

THE FARR TELEPHONE AND CONSTRUCTION SUPPLY COMPANY, Chicago, Ill., occupies a fine new building at 118 and 120 Jackson Boulevard West. A neat circular containing a half-tone illustration of the building, a biographical sketch of Mr. Charles W. Farr and a portrait, reprinted from a leading telephone journal, and an invitation to its patrons to make use of its information department, is being sent out.

THE HAINES & NOYES COMPANY, Chicago, Ill., report a large number of contracts closed recently, among which may be mentioned that with the Globe Wernicke Company, Chicago, Ill., for a large intercommunicating system. The home office of the Haines & Noyes Company has closed contracts for ten apartment telephone systems in Chicago. This company is also equipping the St. Anthony Hospital with house telephones, also the J. S. Ford-Johnson Chair Factory, Michigan City, Ind.

PENBERTHY INJECTOR COMPANY, Detroit, Mich., manufacturer of the Penberthy improved injector, has reestablished its plant and is working a day and night shift on account of a very large demand for these injectors. A serious accident at the company's plant, due to the explosion of a boiler used in the works, resulted in the death of a number of persons last November. The recent inquest lasting nine and a half days has resulted in a verdict which completely exonerates the Penberthy company and its engineer from responsibility for this accident.

THE SAFETY ELECTRIC SWITCH COMPANY, Providence, R. I., announces that it has purchased the plant, the patents and the patent rights of the Hope Electric Appliance Company, of Providence, as well as numerous other patents covering late and approved types of make and break switches. The factory will be located at Providence. The company will manufacture several types of switches for any potential, and also the Hope arc cutout boxes, fire-proof hanger boards, mast-arms and detachable pole steps. The company states that it will be in an excellent position as to workmanship and efficiency to supply the trade with its varieties of electric appliances.

THE NEW YORK CENTRAL RAILWAY COMPANY, through its publication department, has issued an artistic thirty-two-page souvenir, entitled "Fifteen Hundred Miles over the New York Central Lines with Prince Henry of Prussia, from Chicago *via* Buffalo, Niagara Falls to Boston, Albany, West Point and New York." It is printed in four colors, contains nineteen half-tone illustrations, two maps, and a splendid title page with an excellent portrait of the Prince. The letterpress is descriptive of the German immigration to America and the trade relations with the German Empire. It gives the itinerary and the most interesting events of the tour. Copies will be sent for four cents in postage, on application to George H. Daniels, general passenger agent, Grand Central Station.

OBITUARY NOTICES

MR. WILLIAM L. ELKINS, JR., of Philadelphia, Pa., died on March 13, at his country home, Menlo Lodge, near Elkins Station, Pa. Mr. Elkins was a son of the traction magnate, and was prominently identified with many business interests, and among others was a director of the Allis-Chalmers Company.

PROFESSOR ALBERT RIPLEY LEEDS, professor of chemistry at Stevens Institute, Hoboken, N. J., died on March 13 of cancer of the stomach. Mr. Leeds resigned his professorship at Stevens a week ago, and gave his library to that institution. Mr. Leeds, who was about sixty years of age, had a national reputation as a chemist, and was the author of many papers on technical and general chemistry.

PERSONAL MENTION

MR. W. R. BRIXEY, who was seriously injured in the recent explosion at the Murray Hill Hotel, has so far recovered as to be enabled to go South. He left New York a few days ago.

MR. LUTHER STIERINGER has gone South to Florida, after a prolonged convalescence following his work at the Pan-American Exposition. Mr. Stieringer will be gone for a couple of months and will study the Charleston Exposition *en route*.

MR. THOMAS D. WATSON has recently severed his connection with the firm of J. J. Jones & Son, after having been with this firm for the past seven years. Mr. Watson goes with William J. Roche, the manufacturer of the New Standard dry batteries and specialties, and takes charge of the sales department.

HOUSTON & KENNELLY, for many years a firm of consulting electrical engineers in Philadelphia, have dissolved partnership. Professor E. J. Houston will remain in Philadelphia, associated with Messrs. McCullagh & Company. Dr. A. E. Kennelly, it is stated, will devote himself hereafter to special research and possibly to university work.

MR. S. L. G. KNOX, who has been engineer in charge of the drafting department of the General Electric Company, at Schenectady, N. Y., and chairman of the committee on mechanical design, has accepted the position of chief engineer and manager of the Bucyrus Company, of South Milwaukee, Wis. Mr. Knox is an associate member of the American Institute of Electrical Engineers.

MR. GEORGE J. CADWELL, known in electric circles through his connection with the Christensen Engineering Company, of Milwaukee, Wis., and at an earlier period with the General Electric Company, has been appointed manager for Powling & Hornisfeger, of Milwaukee, Wis., manufacturers of electric cranes, for the territory embracing Philadelphia and New York cities. Mr. Cadwell is a young man of ability and energy, a valuable man in any department of the electrical field, and will no doubt prove an able representative of the excellent firm which he will represent in the East.

MR. FREDERICK L. HUTCHINSON has just taken the position of advertising manager for the Christensen Engineering Company, of Milwaukee, Wis. Mr. Hutchinson graduated from Cornell in 1893 and went into the employ of the Westinghouse Electric and Manufacturing Company at the Newark, N. J., works in June of that year. He was transferred to the East Pittsburgh works in 1895, and was connected with the head sales office during the next two years. At that time he was transferred to the department of the Westinghouse Companies and remained there until about a year ago, resigning to take charge of the C. W. Hunt Company's publication department. He resigned this position recently to go to Milwaukee. Mr. Hutchinson, while at Pittsburgh, produced nearly all the circulars, etc., for the Westinghouse Electric and Manufacturing Company, also a large number of technical articles in the scientific and engineering press.